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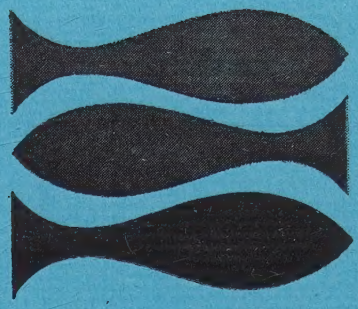


INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

ANNUAL REPORT 1960

VANCOUVER, CANADA, 1961

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

MEMBERS - 1960

CANADA

George R. Clark
John M. Buchanan
James C. Cameron
Roger T. Hager

UNITED STATES

Milton E. Brooding
Edward W. Allen
John H. Clawson
Arnie J. Suomela

JAPAN

Iwao Fujita
Haruki Mori (to September 22, 1960)
Yoshimitsu Ando (from September 22, 1960)
Kenjiro Nishimura
Koichiro Kobayashi (to August 12, 1960)
Kenkichi Nakabe (from August 12, 1960)

SECRETARIAT

Roy I. Jackson, Executive Director
Hiroshi Kasahara, Assistant Director

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

Established by Convention between Canada, Japan and the United States for the Conservation of the Fisheries Resources of the North Pacific Ocean

ANNUAL REPORT 1960

OFFICES: 6640 Northwest Marine Drive
Vancouver 8, B.C., Canada

LETTER OF TRANSMITTAL

The Chairman of the International North Pacific Fisheries Commission presents his compliments to the Contracting Parties and their Commissioners and has the honour to transmit herewith an Annual Report describing the activities of the Commission during the year terminating with the end of the Seventh Annual Meeting on November 11, 1960.

The Report is presented in compliance with Article III (1) (f) of the International Convention for the High Seas Fisheries of the North Pacific Ocean and Rule 14 (f) of the Rules of Procedure.

GEORGE R. CLARK,
Chairman.

FOREWORD

On June 12, 1953, the governments of Canada, Japan and the United States brought the International Convention for the High Seas Fisheries of the North Pacific Ocean into force for the purpose of ensuring the maximum sustained productivity of the fishery resources of the Convention area. The Convention provided for the establishment of the International North Pacific Fisheries Commission to promote and coordinate the necessary scientific studies and to recommend the required conservation measures in order to secure the maximum sustained productivity of fisheries of joint interest.

The Commission, which began its work in 1954, now presents the seventh annual report of its activities and achievements. The report contains a summary account of the Seventh Annual Meeting of the Commission. At the Commission's annual meetings formal reports of progress in all phases of the Commission's work are received, and policies and plans for future work are developed and adopted. Scientific investigations, programed and coordinated by the Commission, have been executed by the fisheries research agencies of the three Contracting Parties. Summaries of the results of research, prepared by these research agencies, are, as usual, included in this annual report. The views expressed in these summaries are those of the authors and not necessarily those of the Commission. The report also contains a brief narrative record of actions taken by the Commission during the year and of the activities of the Secretariat.

During 1960, agencies participating in the Commission's research program emphasized the analysis of data collected during the intensive program of research on salmon on the high seas and the reporting and publication of the results of these investigations. Research on salmon conducted under the terms of the Protocol to the Convention continues to disclose extensive intermingling, in the Aleutian area, of various populations of salmon from the Asian and North American continents. At the 1960 Annual Meeting, however, the Commission, having received no agreed interpretation of the Protocol from the Contracting Parties, as requested a year previously, was unable to consider whether the provisional dividing line for salmon fishing should be confirmed or changed. Hence, the dividing line for salmon fishing, at or near 175° West Longitude, remains provisional in nature and unchanged in position.

In 1960, in accordance with provisions of the Convention, the Commission again studied the stocks of fish under abstention for the purpose of determining whether or not it should recommend that any stock be removed from the list contained in the Annex. No recommendations for changes in abstention with respect to salmon or halibut or herring stocks were made at the Seventh Annual Meeting. It should be noted, however, that the Contracting Parties acted affirmatively on a recommendation with respect to the stocks under abstention made by the Commission at its Sixth Annual Meeting (1959). As a result, on May 24, 1960, herring off the coast of Alaska were removed from the Annex to the Convention and abstention by Japan from fishing this stock is no longer required.

The Commission, in endeavouring to carry out its duties under the Convention, is keenly aware of the rapid developments that are taking place in the fisheries of the North Pacific Ocean. The effects of such changes are being closely watched, to the extent provided in the Commission's terms of reference. Entry of another country into the king crab fishery of the eastern Bering Sea, for example, has a direct bearing on the program of research being carried out on this stock by the Commission. Efforts will be made to obtain statistics from this operation.

In considering the complex and numerous fisheries problems that face the Commission, a quotation from the opening address of the Chairman of the Commission, Mr. George R. Clark, at the Seventh Annual Meeting is pertinent:

> " This Commission continues to be the best and only organization for the solution of these problems. We have all the essentials in our hands—firm friendship between the member countries—competence and experience in our joint scientific research—ability and understanding and experience among the Commissioners. I submit that it can only be concluded that the efforts of the Commission will continue and that success will increase resulting in benefits designed, as stated in part in the preamble of the Convention ' to best serve the common interest of mankind as well as the interests of the Contracting Parties ' ".

ROY I. JACKSON,
Executive Director.

TABLE OF CONTENTS

Letter of Transmittal

Foreword

Page

I. Report of the Seventh Annual Meeting—1960 1

1. Time and place of meeting 1
2. Participants 1
3. The agenda 1
4. Opening session 1
5. Procedures for the meeting 2
6. Consideration of administrative matters 3
7. Implementation of the provisions of the Protocol 4
   (a) The requirement 4
   (b) Interpretation and implementation of the Protocol 4
   (c) Progress in research 4
      i. Restatement of research objectives 4
      ii. Expediting analysis of research results 5
      iii. Distribution of sockeye salmon 5
      iv. Distribution of pink salmon 7
      v. Distribution of chum salmon 7
      vi. Distribution of coho and chinook salmon 8
      vii. Oceanography of the North Pacific 8
   (d) Reporting of the results of research 9
      i. Rapporteurs for salmon research 9
      ii. Research reports from national sources 9
      iii. Joint report on salmon distribution 9
      iv. Joint report on oceanography 9
   (e) Future research plans 10
   (f) Research plans for 1961 11
      i. Program of research under the Protocol for 1961 11
8. Implementation of the provisions of Article III (1) (a) of the Convention (Abstention) 11
9. Implementation of Articles III (1) (c) (i) and III (1) (c) (ii) of the Convention, with respect to king crab 12
10. Implementation of the general provisions of the Convention 13
11. New officers 13
12. Future meetings 13

13. Closing statements 13
Appendix I. List of Participants 15
Appendix II. Agenda 19

II. Administrative Report for 1960 20
Appendix I. Auditors' Report 24

III. The Research Program
A. Research by Canada in 1960 26
B. Research by Japan in 1960 57
C. Research by the United States in 1960 76

I. REPORT OF THE SEVENTH ANNUAL MEETING
of the
INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

Vancouver, British Columbia, November 7 to 11, 1960

1. Time and Place of Meeting

The Seventh Annual Meeting of the International North Pacific Fisheries Commission was held at the Georgia Hotel in Vancouver, British Columbia, Canada, from November 7 to 11, 1960, under the chairmanship of Commissioner George R. Clark of Canada.

A number of committees established by the Commission held sessions prior to and concurrently with the plenary sessions. The Scientific Sub-Committee of the Ad Hoc Committee on Abstention studied the scientific aspects of the abstention cases at the Biological Station of the Fisheries Research Board of Canada at Nanaimo, B. C., at intervals from October 17 to 21. The Editorial Referees and the Long-Range Research Planning Sub-Committee of the Committee on Biology and Research also met in Nanaimo at the same time and place. The Standing Committee on Biology and Research began its meetings on October 24 at Harrison Hot Springs, British Columbia, under the chairmanship of Commissioner John H. Clawson of the United States. Dr. A. W. H. Needler of Canada acted as convenor of the scientific sessions. The Ad Hoc Committee on Abstention began its sessions on November 1 under the chairmanship of Commissioner George R. Clark of Canada. Mr. Clark was also chairman of the Ad Hoc Committee on the Protocol, which first met on November 3. The Standing Committee on Finance and Administration began its work on November 7 under the chairmanship of Commissioner Kenjiro Nishimura of Japan.

2. Participants

The members of the Commission were, as usual, accompanied by advisors, experts and, in the case of the United States delegation, members of its Advisory Committee. At the invitation of the Commission, official observers were present representing the International Pacific Salmon Fisheries Commission, the International Pacific Halibut Commission, the Inter-American Tropical Tuna Commission, the International Commission for the Northwest Atlantic Fisheries and the Union of Soviet Socialist Republics. The total number of accredited participants for the meeting was 122*; including 22 representatives from Canada, 19 from Japan, 60 from the United States, 13 observers and 3 permanent and 7 temporary members of the Secretariat.

Lists of the officers and members of the Commission and its various committees and the names of all accredited participants in the Seventh Annual Meeting are given in Appendix I of this report.

3. The Agenda

The Commission adopted, without change, the provisional agenda for the Seventh Annual Meeting which had previously been circulated sixty days in advance of the meeting. The agenda may be found in Appendix II of this report.

4. Opening Session

The Commission held the opening plenary session of its Seventh Annual Meeting in the Ballroom of the Georgia Hotel in Vancouver on November 7. In accordance with a standing decision of the Commission, attendance was open to the public and members of the press. The Chairman opened the meeting and introduced His Worship Frank Baker, the Acting Mayor of Vancouver, who delivered an address of welcome and wished the Commission success in its deliberations.

The Honourable J. Angus MacLean, Minister of Fisheries for Canada, then welcomed the Commission on behalf of the Government of Canada. In his address Mr. MacLean spoke of the significant accomplishments of the Commission in developing and implementing its programs of scientific research. Canada viewed the North Pacific Convention as of general benefit to the member countries. The fisheries with which the Commission is concerned are of extreme importance to Canada and the Minister hoped that the Convention would continue into the future for the reason that international cooperation, based on mutual interest and respect, is essential not

* Two national delegation members also acted as observers for invited organizations.

only in matters pertaining to fisheries, but in all fields affecting the community of nations.

Commissioner Kenkichi Nakabe responded to the addresses of welcome on behalf of the Japanese delegation. Mr. Nakabe expressed the pleasure of the members of his delegation at again meeting their colleagues from Canada and the United States and the observers in attendance at the meeting. He stressed the dependence of the Japanese people on the food resources of the sea and called attention to Japan's efforts toward rational utilization and conservation of fisheries resources. International cooperation is an essential ingredient of conservation of fisheries on the high seas. Mr. Nakabe noted the severity of the obligation to abstain from fishing as imposed by the Convention, and stated that the abstention provisions of the Convention should be strictly interpreted and their fulfillment adequately demonstrated on a scientific basis. Continuation of frank discussions of problems within the Commission would do much to further the mutual understanding and friendship of the member countries.

Commissioner Milton E. Brooding, Chairman of the United States National Section, addressed the opening session on behalf of the members of his delegation. He expressed their pleasure at returning to Vancouver and again meeting with their colleagues in the Commission. Mr. Brooding stressed the progress in research which had been achieved under the Commission's program and stated that failure of the Commission to draw valid and reasonable conclusions from these findings would discredit the approach used by the Commission in the eyes of the world. Mr. Brooding noted that perfection in matters of biological research in fisheries could not be achieved but called for reasonableness in evaluating existing facts and reaching objective conclusions therefrom.

Commissioner Roger T. Hager addressed the opening session on behalf of the Canadian delegation. He expressed the thanks of his delegation for the address given by the Minister of Fisheries and for the welcome extended by the Acting Mayor of Vancouver. Mr. Hager stressed the need to continue sound conservation regulations to ensure the maintenance and rational exploitation of the fisheries resources of the North Pacific. He noted that at the preceding annual meeting the Canadian Section had proposed certain courses of action for consideration by the Commission; namely, publication of abstention reports submitted by governments, publication of the results of scientific research and a review of the research program to determine whether changes should be made. The Canadian Section was gratified that the Commission had adopted these proposals and that work on them had been proceeding. The members of the Canadian Section look forward to continued cooperation and progress through joint efforts with their colleagues from Japan and the United States.

The Chairman of the Commission, Mr. George R. Clark, expressed the Commission's appreciation to the Minister of Fisheries and the Acting Mayor of Vancouver and welcomed the delegates and observers to the Seventh Annual Meeting. Mr. Clark briefly reviewed the history and accomplishments of the Commission. He called attention to the application of the abstention principle and noted that its practical and objective nature had been demonstrated when the member governments accepted the Commission's recommendation and removed Alaska herring from abstention on May 24, 1960, because the Commission had demonstrated that these stocks were not being fully utilized.

Mr. Clark noted that there has never been a case of violation of the abstention provisions of the Convention by any abstaining party. He spoke of the complexity of the scientific problems facing the Commission and the need to take action on the basis of reasonable interpretations of available data. He commented on progress being made in the scientific investigations and called attention to the fact that the Commission had asked the Contracting Parties to provide it with an agreed interpretation of the Protocol to the Convention. Mr. Clark called for increased efforts in publication of the scientific findings of the Commission. He noted the sensitivity of salmon stocks to over-fishing and emphasized that restraint in fishing was the single most important factor in maintaining the abundance of salmon stocks. It was the Chairman's belief that this Commission continues to be the best and only organization for solution of the problems with which it is concerned.

5. Procedures for the Meeting

In response to a view expressed by the United States, the Commission again reviewed its policy with respect to attendance at plenary sessions. However, the Commission did not agree to change the policy with respect to attendance established at the 1956 Annual Meeting, which reads as follows:

> " The first plenary session of annual meetings of the Commission shall be open to the public unless otherwise decided by the Commission. All non-public meetings of the Commission and meetings of its standing committees shall be open to guests and observers who have been invited by the Commission, except meetings which may be held *in camera.*"

With respect to matters of publicity, the Commission agreed to follow established practice, in which each national section designates a representative to work with the Chairman of the Commission and the Secretariat in preparing information for the press. Commissioners John M. Buchanan of Canada, Kenjiro Nishimura of Japan and Milton E. Brooding of the United States were designated by their respective national sections as representatives on the press committee.

Established policy with respect to handling of minutes of plenary sessions was continued. The Secretariat prepares draft summary minutes of each plenary session for review by each national section, following which any needed revisions are made and the minutes submitted for approval at a subsequent plenary session. Such summary minutes, after approval, comprise the only official records of the Commission's deliberations.

6. Consideration of Administrative Matters

6 (a) Report of the Chairman

The address of the Chairman of the Commission, Mr. George R. Clark of Canada, as given at the opening plenary session, was adopted by the Commission as the Chairman's report for 1960 (Item 8, INPFC Doc. 435).

6 (b) Report of the Secretary

The Secretary of the Commission, Mr. Edward W. Allen of the United States, stated that the functions of his office were reported in the Administrative Report for 1960 (INPFC Doc. 388) being submitted by the Secretariat. On this basis, members of the Commission agreed that the Administrative Report for 1960 should be considered as the report of the Secretary of the Commission.

6 (c) Submission of Reports by the Secretariat

The Executive Director submitted the following reports to the Commission on behalf of the Secretariat:

i. Auditors' Report for the fiscal year ended June 30, 1960 (INPFC Doc. 383).

ii. Budget estimate for 1961–62 and budget forecast for 1962–63 (INPFC Doc. 380).

iii. Administrative Report for 1960 (INPFC Doc. 388).

iv. Comments on the form and nature of the reports submitted in 1960 under Articles III (1) (c) (iii) and X (2) of the North Pacific Convention (INPFC Doc. 389).

v. Statistical Yearbook for 1959.

These reports were referred to the appropriate committees for information, review and report. Disposition of the reports by the Commission is recorded in the sections of this report dealing with the work of the various committees.

6 (d) Report of the Standing Committee on Finance and Administration

Matters of finance and administration on the agenda for the plenary sessions (Items 7 and 15) were referred to the Committee on Finance and Administration for consideration. The Committee, under the chairmanship of Mr. Kenjiro Nishimura, and with members as listed in Appendix I of this report, made a number of recommendations to the Commission, which adopted them. The recommendations are summarized below:

i. The Committee approved the Commission's accounts and the report of the auditors, Peat, Marwick, Mitchell & Co., for the fiscal year ending June 30, 1960, and recommended approval by the Commission. Expenditures for operations of the Commission's Secretariat totalled $47,841.88, Canadian funds, for the period. The auditors' report appears as an appendix to Part II of this annual report. The Committee also recommended that the Secretariat be instructed to continue to provide statements of explanation of items in the auditors' report and the relationships between items.

ii. The Committee recommended that the Commission adopt a budget totalling $53,460 (Canadian funds) for the operation of its headquarters for the fiscal year beginning July 1, 1961. Each Contracting Party contributes one-third of the funds required for the operation of the Secretariat.

iii. The Committee also presented to the Commission a budget forecast totalling $55,089 (Canadian funds) for the operation of its headquarters for the fiscal year beginning July 1, 1962. The budget forecast is intended for the guidance of the national sections and is not to be considered for adoption by the Commission until the Eighth Annual Meeting in 1961.

iv. The Administrative Report for 1960 (INPFC Doc. 388), by the Executive Director, was reviewed by the Committee on Finance and Administration, in accordance with instructions given by the Commission. The Committee recommended to the Commission that the report be accepted as a record of the activities of the Secretariat during the preceding year. The report in question forms Part II of this annual report.

v. The Committee reviewed a report entitled "Comments on the form and nature of the reports submitted in 1960 under Articles III (1) (c) (iii) and X (2) of

the North Pacific Convention" (INPFC Doc. 389). This report had been submitted to the Commission by the Secretariat and referred to the Committee on Finance and Administration for consideration. The Committee recommended that the report be accepted by the Commission and that copies should be made available to those concerned with preparation of similar reports under Articles III and X in the future. The Japanese members of the Committee requested that the reports under Convention Articles III and X be submitted earlier than the presently agreed date of 30 days in advance of the first plenary session each year. This would allow more time for study of their contents prior to annual meetings.

The Japanese members of the Committee called attention to a request they had made two years ago, for information, as soon after the fact as possible, on major changes in fishing regulations made during the season each year for the stocks and areas under abstention. Information on the conservation objectives of such major changes should also be included.

vi. The Committee on Finance and Administration recommended that the first plenary session of the Eighth Annual Meeting of the Commission should be held on Monday, November 6, 1961, in Tokyo, Japan. It was further recommended that the period beginning on October 23, 1961, and extending to the end of the Eighth Annual Meeting should be designated as the period within which the time and place of committee sessions might be arranged by consultations between their respective chairmen and the Secretariat. If any sub-committee sessions are required in advance of this date, the Committee recommended that the week of October 16 be available for scheduling such sessions.

7. Implementation of the Provisions of the Protocol

7 (a) The Requirement

Under the terms of the Protocol to the North Pacific Convention the Commission is required to determine if salmon originating in the rivers of Canada and the United States of America are intermingling in the ocean with salmon originating in the rivers of Asia. If areas of intermingling are found, and they have been found, the Commission is to conduct studies to determine a line or lines which best divide salmon of Asian origin and salmon of Canadian and United States of America origin and to determine whether it can be shown beyond a reasonable doubt that the new line or lines more equitably divide such salmon stocks than the provisional lines specified in the Annex to the Convention. In accordance with these determinations the Commission shall recommend that such provisional lines be confirmed or that they be changed in accordance with these results.

Two committees have assisted the Commission over a period of years in dealing with the problems raised by the Protocol to the Convention. The Standing Committee on Biology and Research is charged with planning and coordinating the scientific investigations of the distribution, origin and abundance of Pacific salmon in the North Pacific Ocean and analyzing and reporting results therefrom to the Commission. The Ad Hoc Committee on the Protocol was established several years ago to study the results of these scientific investigations for the purpose of recommending to the Commission what action, if any, may be desirable or necessary for the discharge of the assignments given in the Protocol.

7 (b) Interpretation and Implementation of the Protocol

During the course of its Sixth Annual Meeting, on November 7, 1959, the Commission decided to inform the Contracting Parties that it had been unable to arrive at an agreed interpretation of the intent of the Protocol to the Convention and to request that the Contracting Parties provide it with such an interpretation as soon as practicable. At the present (Seventh) annual meeting, the Commission, noting that an agreed interpretation of the Protocol had not yet been received from the Contracting Parties, made no recommendation regarding implementation of the Protocol. That is, the Commission found itself unable to recommend either that the provisional lines be confirmed or that they be changed, because it does not have an agreed principle for dividing the stocks to which the results of research could be applied.

7 (c) Progress in Research

The Commission's investigations of the origin, distribution and abundance of salmon on the high seas continued on an intensive level in 1960. As has been the case since investigations began in 1955, research activities were planned and coordinated by the Commission, acting through its Committee on Biology and Research. Investigations continued to be actually carried out by fisheries research agencies in the three member countries.

i. *Restatement of research objectives.* During 1960, the Commission developed and adopted a statement which defines the objectives of research being conducted on the scientific problems raised by the Protocol to the Convention. The statement, which follows, does not represent a change in research objectives, but

incorporates the lessons and limitations learned by experience in the past five years:

"To determine the distribution and abundance of continental stocks of salmon in the northern Pacific Ocean and in the Bering Sea.

"a. The three most abundant species, i.e., sockeye, chum and pink salmon, are of primary concern.

"b. We are seeking information on the abundance, origin, distribution and intermingling of salmon on the high seas in a quantitative sense.

"c. The period of each year with which we are concerned is the late spring and summer.

"d. We are seeking knowledge of average conditions with respect to the distribution and intermingling of salmon by conducting research for a number of years and knowledge of the factors causing year-to-year fluctuations.

"e. We are considering separately the mature and immature forms of these species of salmon, since their distribution and movements in offshore waters are different.

"f. We have become aware of the essential dynamic nature and variability of abundance, distribution and intermingling of salmon on the high seas. We must expect that it will be very difficult to forecast many of the factors which will control abundance, distribution and intermingling in the future."

ii. *Expediting analysis of research results.* Throughout 1960 the Commission and the agencies participating in the research program placed special emphasis on expediting the analysis, interpreting and reporting of the great volume of research information which had been obtained during the preceding five years. Details of these activities will be reported in subsequent sections of this annual report. In June of 1960, subcommittees of the Committee on Biology and Research met in Tokyo to develop long-range research plans and to make recommendations for expediting the interpretation and publication of the results of Commission research. Joint working parties, composed of scientists from the three countries, are actively at work on reports on the oceanography of the sub-Arctic waters of the North Pacific and on the distribution of salmon on the high seas. During the Seventh Annual Meeting, these groups, and a number of other sub-committees dealing with distribution of salmon by species, and various other special topics, continued their work.

At the Seventh Annual Meeting, for the first time, the Committee on Biology and Research used a new system for reporting to the Commission the results of research on the three major salmon species—sockeye, pink and chum salmon. Individuals were designated prior to the meeting to prepare a synopsis of knowledge on the origin, distribution, abundance, movements, etc., of each of these species. Mr. F. C. Cleaver of the United States was chosen as the rapporteur for sockeye salmon. Mr. Teruo Ishida of Japan was chosen as the rapporteur for pink salmon. Dr. M. P. Shepard of Canada was chosen as the rapporteur for chum salmon. These scientists, working with the assistance of appointed corresponding scientists in the other member countries, prepared reports, as individuals, on the species with which they were concerned. The individual reports on each species were presented to the Committee. The Committee referred them to sub-committees for each species, in which the rapporteur became chairman and the correspondents became the members. Using the reports of the rapporteurs and other available materials as required as the basis for their work, these sub-committees produced jointly-agreed reports on each species. These sub-committee reports on species, each of which is summarized below, were submitted to and adopted by the Commission. Arrangements for the continuation of the work of the species rapporteurs are described in Section 7 (d) i of this report.

iii. *Distribution of sockeye salmon.* The report of the Sub-Committee on Sockeye Salmon, as adopted by the Committee on Biology and Research and the Commission, is contained in full in INPFC Document 432, the Report of the Committee on Biology and Research for 1960. The following summary of the report is quoted verbatim from Document 432:

"A. Inshore distribution of sockeye was considered, and it was agreed that the density, range of distribution and pattern of intermingling might be affected by stock sizes as well as environmental factors, and that coastal catches and escapements may be used as indices for estimating the sizes of stocks. Inshore sockeye salmon catches have averaged about 8 million in British Columbia, 11 million in Alaska and 2 million fish in Asia for the period 1952–1959.

"B. Offshore distribution of sockeye salmon and the year-to-year changes in abundance were discussed. It was pointed out that studies of the relationship of sockeye to their environment are in an initial stage. Information on vertical distribution of sockeye is available only for the western Gulf of Alaska area. Sockeye are widely distributed offshore from as far south as 43°N. in the western (48°N. in the eastern) Pacific Ocean to the northern Bering Sea. The distribution shifts south in the winter months and north in the summer months.

"C. The racial studies may be summarized as follows:

" 1. The scale studies suggest that in 1957, 1958 and 1959 maturing fish of the Rivers Inlet-Smith Inlet type were found in the Gulf of Alaska to as far west as 155°W. longitude. Immature fish of this type were found mainly farther west than maturing fish, and as far west as 170°W. longitude.

" North of the Aleutians, Asian stocks predominated from the Asian coast eastward to at least 170°E. longitude, and occurred at least to 180°.

" South of the Aleutian Chain, Asian fish predominated from the Asian coast eastward to about 175°E., and in the two largest samples, to 180°.

" Western Alaska stocks extended from Bristol Bay in a wide tongue along and north of the Aleutian Islands and predominated to about 175°E longitude.

" Where samples were replicated as between 1956, 1957 or 1958, the general features of the occurrence of the sockeye of the two origins in the samples were similar in the years concerned. In a number of areas no replications have yet been made. The stocks from the two continents intermingled over a wide area from at least 170°E. to at least 175°W. in all three years, but it should be noted that no samples were available eastward of 175°W. in any of these years, south of the Aleutians.

" 2. Evidence has been obtained which indicates that an antigen which is correlated with maturity of female salmon is a reliable indicator of maturation as early as April.

" 3. As outlined in Table 8 and Figure 4 (of the preceding section on morphology), during the years 1956, 1957, 1958 and 1959 for the period of late May and June, the morphology studies shows:

" (a) In the Bering Sea, in the 180° band[1] and eastward, the average percentage of Western Alaska morphotype in the samples ranged from 65 to 90 per cent. Westward from this band, the average percentages of Western Alaska morphotype in the samples decreased. In the 175°E. band and westward, the average percentage of southwest Kamchatka morphotype ranged from 61 to 100 per cent.

" (b) In the North Pacific Ocean, from the Asian coast out to the 170°E. band, the average percentages of Western Alaska morphotype in the samples ranged from zero to 40 per cent. In the 175°E. band, the average percentages of Western Alaska morphotype ranged from 11 to 45 per cent, except for 67 per cent in 1956. In the 180° band and eastward, the average percentage of Western Alaska morphotype ranged from 72 to 85 per cent in 1959, but in 1958 the single sample (taken in the 180° band) contained none of this type.

" (c) In the Bering Sea eastward from the 180° band and in the North Pacific westward from the 175°E. band, sampling from 1956 to 1959 was sufficiently intensive to suggest that the approximate ranges of percentages cited above reflect the relative proportions of the southwest Kamchatka and Western Alaska morphotypes present in these areas.

" 4. The parasite studies of samples collected in 1959 lead to the following conclusions:

"A. *Maturing sockeye*

" (1) In the Bering Sea from 170°W. to 180° samples taken in the latter half of June consisted largely of fish of Bristol Bay origin.

" (2) Immediately south of the Aleutians from 169°W. to 175°E. in late May and early June the samples consisted predominantly of fish of Bristol Bay origin.

" (3) Large numbers of Bristol Bay sockeye also inhabited the northern Gulf of Alaska in late May and early June.

" (4) It appeared that Asian sockeye formed the majority in two Bering Sea samples at 171°E. in early June, and that sockeye during late May to late June from 175°E. west to Asia, south of the immediate neighbourhood of the Aleutians, were mainly of Asian origin.

" B. *Immature sockeye*

" (1) Asian sockeye were found as far east as 170°W. south of the Aleutians. Bristol Bay sockeye were found as far west as 175°E., both south of the Aleutians and in the Bering Sea, and as far east as 145°W.

" 5. The tagging studies have shown:

" (1) Mature sockeye present off the southeast coast of Kamchata as far east as 170°E. were virtually all bound for Asian streams.

" (2) During late May and June:

" (a) The great majority of mature sockeye

[1] The " band " referred to in this quotation of the summary from the Report of the Sub-Committee on Sockeye Salmon are described in the body of the report as follows: " The Bering Sea and North Pacific Ocean are sub-divided into 5° longitudinal intervals, with longitudes ending in 5 and 0 being the mid-points of the intervals. These are referred to as " bands " and are identified by their central longitudes.

immediately south of the Aleutians at least as far west as 180° were bound for Bristol Bay. Many of these Bristol Bay fish were later intercepted by the mothership fishery operating in the southern Bering Sea.

" (b) Westward from 180° immediately south of the Aleutians, tagging was less concentrated but still, as far west as Attu (172°E.) Bristol Bay fish formed a substantial proportion of maturing fish present.

" (c) Virtually all the mature sockeye in the Pribilov area and in the Bering Sea immediately north of the Aleutians westward to 177°W. were bound for Bristol Bay.

" (d) Tagging in the Bering Sea (both near the Aleutians and further north) westward from 177°W. was very sparse but from taggings as far west as 177°E., recoveries were made only in Bristol Bay and in the mothership fishery near where the fish were tagged, suggesting that Bristol Bay sockeye formed a majority of the matures in this area.

" (e) South of the Aleutians, and mainly within 30 miles of the Islands, the direction in which the United States seines were held open while fishing has demonstrated a strong westward movement of sockeye salmon.

" In the Bering Sea no clear-cut picture of direction of movement was obtained, except from seinings well to the east where eastward movements were indicated. Seining together with tag recoveries have also demonstrated the relative importance of Amchitka (180°) and Amukta (172°W.) Passes as routes of entry for sockeye salmon into the Bering Sea."

iv. *Distribution of pink salmon.* The report of the Sub-Committee on Pink Salmon, as adopted by the Committee on Biology and Research and the Commission, is contained in full in INPFC Document 432, the Report of the Committee on Biology and Research for 1960 (INPFC Doc. 432). The following summary of the report is quoted verbatim from Document 432:

" The above full report contains a thorough discussion of the subject for areas for which data are available. Offshore and coastal distributions are discussed with respect to catches and research findings. The major stocks contributing to the high seas populations are indicated in the light of tagging studies, scale studies and morphometric studies. For the sake of brevity and of pertinence to the Protocol problem, this summary deals only with those stocks which pass through Aleutian waters during late spring and summer.

"All phases of the research to date agree in showing that only three principal groups of pink salmon inhabit Aleutian waters.

" These are:

" 1. Asian stocks (principally those from East Kamchatka)

" 2. Northwest Alaskan stocks (N. side Alaska Peninsula to Kotzebue Sound)

" 3. Local Aleutian Island stocks (these are apparently relatively minor numbers appearing only late in the summer).

" During odd-numbered years for which comparable data are available (1957 and 1959), Asian pinks greatly dominated Aleutian waters. This dominance extended at least to the eastern Aleutians (163°W.) in late May of 1957, and at least to 167°W. in early June of 1959.

" Pinks were so scarce in Aleutian waters sampled in 1956 that conclusions as to limits of intermingling may not be drawn. In 1958 they were again relatively scarce, but evidence showed Northwest Alaska pinks present westward at least to the Central Aleutians (177°E.), and Asian pinks present eastward at least to this point. Using relative production in pertinent Asian and Alaskan areas, these two stocks could have been mixed in approximately equal proportions in Central Aleutian waters. In 1960, pinks were relatively abundant for an even year in Aleutian and Bering Sea areas. Tagging was cited to show important numbers of both Asian and Alaskan pinks mixed in the central and eastern Aleutians (167°W.–177°W.). No pinks were tagged east of 167°W. Only Asian recoveries were received from taggings west of 177°W.

" In general, pink salmon research by the three nations to date has provided much new basic data on oceanic distribution, movements, and habits which may be applied to other species as well."

v. *Distribution of chum salmon.* The report of the Sub-Committee on Chum Salmon, as adopted by the Committee on Biology and Research and the Commission, is contained in full in INPFC Document 432, the Report of the Committee on Biology and Research for 1960. The following summary of the report is quoted verbatim from INPFC Document 432:

" a. Asian chum salmon stocks are more abundant than those originating in North America. On both continents, they are widely distributed, inhabiting streams and rivers of northern Japan, the northern Japan Sea, Okhotsk Sea, North Pacific, Bering Sea and Arctic Ocean coasts of the U.S.S.R., and of the entire North American coastline from

Oregon northward to the Mackenzie River on the Arctic Ocean. On both continents the more northerly runs spawn in the summer (mainly June to September) whereas in southern streams (especially Hokkaido and southern British Columbia) the fish spawn in the autumn (September to December). The summer-run U.S.S.R. stocks of the Sea of Okhotsk and Kamchatka are the most abundant of all.

" b. Chum salmon, migrating to sea as fry in the spring and early summer, become distributed throughout most of the North Pacific and Bering Sea north of the Sub-Arctic front by the time they have completed their first year at sea.

" c. Tagging from 1956 to 1959 indicates that the chums originating in North America and Asia intermingle extensively in the central North Pacific and Bering Sea.

" (i) Fish tagged as far west as 177°W. in the Aleutian area have been recovered in North America and some tagged as far east as 163°W. have been recovered in Asia. Because extensive taggings have not been conducted immediately eastward of 163°W., the eastern extent of the distribution of Asian chum salmon cannot be determined from tagging.

" (ii) In the Bering Sea north of 55°N., chums tagged as far east as 170°W. have been recovered in Asia and some tagged as far west as 175°W. have been recovered in North America. Tagging in this region, however, was not as extensive as it was near the Aleutians and consequently the results may not indicate the full range of intermingling.

" (iii) Thus, intermingling between fish of North American and Asian origins is known to occur between 163°W. and 177°W. in the Aleutian area and at least between 170°W. and 175°W. in the Bering Sea.

" (iv) Both in the Aleutian area and in the Bering Sea north of 55°N., recoveries from taggings of fish westward from 170°W. were mainly made in Asia whereas those from tagging eastward from 170°W. were made mainly in North America.

" (v) In the area of intermingling, fish originating in both northern (summer-run) and southern (autumn-run) streams of Asia were present. Almost all the North American fish present came from northern (summer-run) Alaskan streams draining into Bristol Bay and the Bering Sea.

" d. Studies of scale characteristics on fish collected in 1956 and 1957 also suggest that intermingling occurs over a broad area. Although the methods used require further testing, the results, in general, parallel those of the tagging studies.

" (i) In the Aleutian area, samples of 4- and 5-year-old fish taken early in the season near 175°W. and westward contained large numbers of fish with scales similar to those of fish sampled in the Kamchatka area of the U.S.S.R. and very few fish with scales similar to those of North American fish. Samples taken eastward of 170°W., on the other hand contained substantial numbers of fish with scales of the North American type and relatively few fish with Asian-type scales.

" (ii) Scale studies indicate that chums originating in the British Columbia-Southeastern Alaska area extend throughout the northern Gulf of Alaska. A few may migrate far westward into the central Aleutian area. Throughout the Gulf, they intermingle extensively with fish originating in Alaska streams northward from Yakutat.

" e. From data collected during 1956 to 1959 it is concluded that, from late May to early September, the approximate division between areas where North American and Asian chum salmon predominated lay somewhere between 170°W. and 175°W. in the Aleutian area and probably between the same longitudes in the Bering Sea between 55°N. and 60°N."

vi. *Distribution of coho and chinook salmon.* Although it had been intended that the rapporteur on chum salmon would also prepare syntheses of the results of research on coho and chinook salmon, the short time available between appointment of the rapporteur and the date of the Seventh Annual Meeting made it impossible for him to prepare material on these species. Further arrangements for the reporting of results of research on these species are described in Section 7 (d)i of this report.

vii. *Oceanography of the North Pacific.* Oceanographers from the participating research agencies of Canada, Japan and the United States are members of a sub-committee which plans oceanographic investigations in the area and analyzes and reports the results of the investigations. Arrangements for preparation of a joint report on the oceanography of the sub-Arctic waters of the North Pacific are described in Section 7 (d) iv of this report of the annual meeting.

The oceanographers considered progress in their investigations and agreed that during the past five years the Pacific sub-Arctic has become one of the best-known regions of the oceans. Although the oceanographic features are fairly well known, work remains to be done in determining which features are related to the abundance, distribution and migration of the salmons. However, the sub-committee was pleased with the evident progress in this direction. It was apparent that the probable winter southern limit of the salmons coincides with the limits of the sub-Arctic region and thus can be defined in physical

oceanographic terms. It appears from the United States work in the Aleutian region that the salmon approach the surface in the vicinity of the cold ridge, where the magnitude of the thermocline is greatest. The depth fishing work done by Canada suggests that the vertical distribution of salmon in the Gulf of Alaska may be associated with the depth and magnitude of the thermocline. The possibility of further such experiments in other areas was discussed and considered desirable.

Plans for oceanographic investigations in 1961 are described in Section 7 (e) of this report of the annual meeting.

7 (d) Reporting of the Results of Research

i. *Rapporteurs for salmon research.* The Committee on Biology and Research agreed to a continuation of the rapporteur system for reporting results of research, in relation to the Protocol problem, on the five major species of salmon at the Eighth Annual Meeting and established terms of reference for the preparation and use of the rapporteurs' reports. The objective of the work of each rapporteur is to prepare for the Committee on Biology and Research a well-documented synopsis, analysis and interpretation of all scientific knowledge available, in relation to the Protocol problem, on his assigned species of salmon. The individual rapporteurs are to have assistance, as required, from correspondents in the other national sections. Their reports are to be considered by appropriate species sub-committees, along with any other pertinent material, and may be used as the bases for the sub-committees' final reports.

ii. *Research reports from national sources.* The Committee on Biology and Research has an established subgroup called the Editorial Referees, one of whose functions is to review scientific materials submitted from national sources for publication in the Commission's bulletin series. In addition, the Editorial Referees are to promote the preparation of additional papers and to plan and coordinate efforts toward joint reporting of the results of INPFC research.

At the Seventh Annual Meeting, the Committee on Biology and Research adopted two reports from the Editorial Referees which recommended a total of eight national reports for publication in the Commission's bulletin series. All of these papers deal with techniques of investigations or results of research being carried out under programs of the Commission.

In addition to the eight papers recommended for publication by the Editorial Referees, four more papers from United States sources were submitted for publication shortly before the Seventh Annual Meeting. A paper from Japan was submitted for publication during the course of the meeting. Lack of time for translation and study of these papers precluded action on their approval during the meeting.

It is noted here that the Commission has also taken steps to publish all of the scientific documents relating to species under abstention. These actions are described more fully in Section 8 of this report.

iii. *Joint report on salmon distribution.* The Commission received a progress report from a joint working party established in 1959 by the Committee on Biology and Research to report on the subject " Distribution of salmon in the high seas of the North Pacific Ocean, including the Bering Sea, without reference to area of origin or intermingling ". This working party, which spent several months in Japan in mid-1960, reported substantial progress on its assignment. A preliminary table of contents for the report has been developed and great amounts of data have been compiled and analyzed for inclusion in the report. The purpose of the report is to bring together, from all known sources, catch, effort and biological data concerning high seas salmon, to list these data in detail as a convenient reference source for scientists engaged in specialized studies and to analyze, illustrate and report on them in a manner most useful to the Commission.

Work on this basic project is continuing; sections of the report dealing with the various species have been assigned to different authors for preparation of draft manuscripts. Work of preparation of the report will continue in 1961. The Commission has agreed, in principle, that the members of the group are to have another joint working session prior to the Eighth Annual Meeting of the Commission, with details to be arranged by correspondence.

iv. *Joint report on oceanography.* At its Sixth Annual Meeting (1959), the Commission established a working party of oceanographers from the three countries to prepare a joint report on the oceanography of the sub-Arctic regions of the North Pacific Ocean in terms adequate for fisheries interpretation. Members of the oceanographic working party have developed and agreed in principle to a table of contents and procedures for preparation of the report. Their recommendations have been approved by the Committee on Biology and Research and the Commission. A division of labour for preparation of drafts of various portions of the report has been established. The working party is seeking to bring its members together during 1961 and hopes that its report can be com-

pleted and presented in manuscript form to the Commission at its Eighth Annual Meeting in November, 1961.

v. *Comprehensive joint report on high seas salmon.* At the Sixth Annual Meeting (1959) of the Commission, the Editorial Referees of the Committee on Biology and Research were instructed to " develop plans for the eventual joint reporting of the results of the research program as a whole ". Since that time, the Editorial Referees, with the assistance of the Secretariat, have developed an outline of a table of contents for a comprehensive joint report on the origin, distribution, abundance and intermingling of continental stocks of Pacific salmon on the high seas. Procedures for the preparation of the initial or " background " chapters have been established. Preparation of the initial chapters is to begin immediately. Each chapter is to be prepared and published separately, and not necessarily in order, except that Chapter I, which is to contain introductory materials and an outline of the whole report, is to be published first. Action toward production of the final chapters of the joint comprehensive report is to be considered at the Eighth Annual Meeting of the Commission.

7 (e) Future Research Plans

At its Sixth Annual Meeting the Commission established a Sub-Committee on Long-Range Research Plans, consisting of two scientists from each country, to work with the Secretariat on problems of long-term planning of research. In accordance with instructions, the Sub-Committee and the Secretariat met in Tokyo in June of 1960 and discussed the status of the present program of research on questions raised by the Protocol, the need for further research and the prospective value of various lines of research. The Sub-Committee met again in the period immediately prior to the Seventh Annual Meeting of the Commission.

The restatement of objectives of research, as developed by this Sub-Committee, has already been given in Section 7 (d) i of this report. The Sub-Committee placed much emphasis on the desirability of completing the analysis of existing data, evaluating the methods of analysis used and determining the necessity and extent of further sampling. Each of the national sections has taken vigourous action toward expediting analysis of existing data. Additional funds are being made available in some instances and effort is being diverted from field work to analysis of data in other instances.

The Sub-Committee recommended that additional use be made of the great volume of scale impressions which have been collected and exchanged between the three national sections. Steps were taken to carry out this recommendation. A special study was made to determine if parasitological information might be used for quantitative determination of distribution of Bristol Bay sockeye salmon. It was concluded that in order to derive precise quantitative information from parasitological data the sampling effort required would be much larger than anything that has been carried out in the past and probably would not be feasible. However, general usefulness of the parasitological data was stressed.

As a result of another of the recommendations of this Sub-Committee, a working party scrutinized the methods of analysis used in salmon racial studies and made a series of recommendations for improving the results of such analyses.

The Sub-Committee noted that Canadian investigations had shown salmon distributed throughout a considerable vertical range in the eastern North Pacific and recommended that comparable studies should be made in the western North Pacific and the Bering Sea. Japanese scientists have undertaken to make such investigations in 1961. Certain United States experiments involving use of a mid-water trawl for studying salmon distribution may also assist in answering this question.

The Sub-Committee recommended that salmon tagging in offshore waters should be further expanded and continued and that the areas of coverage should be planned cooperatively. United States scientists reported that it was not feasible to expand tagging operations in 1961 beyond the level of 1960. However, it was noted that the United States tagging effort is already on a large scale and that improvements in tagging techniques and greatly increased rates of returns of tags have, in effect, increased the scale of operations. Canada is providing two tagging vessels in 1961. One vessel will employ purse seines and the other will employ floating longlines for capturing salmon for tagging. Japan will expand her tagging efforts to the eastward in 1961.

The Sub-Committee continued preliminary discussions of the questions of methods of determining natural mortality rates of salmon on the high seas. It agreed that such knowledge is relevant to the Protocol question. Preliminary views on methods of estimation of natural mortality of salmon were submitted and/or discussed. Further consideration of the problems involved will be undertaken prior to and at the 1961 Annual Meeting of the Commission.

7 (f) Research Plans for 1961

i. *Program of research under the Protocol for 1961.* Each member country submitted tentative plans for 1961 investigations on problems raised by the Protocol. In general, research operations will be continued at about the same level as in past years. The tentative plans did not indicate that there were undesirable overlaps or gaps in the anticipated coverage by research vessels. All national sections will exchange detailed cruise plans through the Secretariat in order that a greater degree of coordination in operations may be achieved. This applies to vessels studying salmon distribution as well as those engaged in salmon tagging operations. Lists of samples required from other sections will be developed and exchanged as soon as possible. Routine exchange of scale impressions, samples and data of all kinds will be continued.

In 1961, Canada will discontinue studies of salmon distribution and divert that vessel time to tagging. Canadian studies of parasites of sockeye salmon, including examination of samples collected in 1959, will be completed and fully reported early in 1961. Studies of chum salmon scales by Canadian scientists will be continued to discover the distribution of stocks of various river origins on the high seas. Two vessels will be employed for tagging of salmon. A purse seiner will operate close to the Canadian coast and a longline vessel will tag salmon in the western part of the Gulf of Alaska. A single, two-vessel, full-scale oceanographic survey of the northeastern North Pacific is planned by Canada in May and June. Analysis and reporting of North Pacific oceanography will be intensified, including allocation of considerable effort to joint reporting. Computation of transport from atmospheric conditions will be continued and improved.

In 1961, Japanese scientists will continue to collect catch statistics and biological data aboard salmon motherships, as in the past. Japanese research vessels will continue to study the offshore distribution of salmon using INPFC standard gillnets and commercial nets. Other Japanese research vessels will tag salmon caught by longlines throughout the Aleutian area and in the Bering Sea. Oceanographic observations in the North Pacific and Bering Sea will be continued. Detailed plans will be forthcoming early in 1961.

United States scientists plan to complete racial analysis of meristic and scale materials of all samples collected through 1960, within the next two years. Of approximately 80,000 salmon collected in past years for racial studies, about 40% remain to be processed. Most of those remaining are pink and chum salmon. In respect to determination of salmon origin by use of serological techniques, United States investigators will concentrate on observed discrepancies between the results of serological analysis and results from other techniques. One United States research vessel will be assigned to the Aleutian area to study variability in salmon distribution and abundance within and between sampling areas. Another vessel, operating in the area on another assignment, may collect some samples at key stations. United States workers will concentrate on completing analysis of all existing material dealing with abundance of salmon on the high seas within the next year or two. Salmon tagging operations, as previously noted, will continue at about the same level of effort as for 1960, insofar as United States vessels are concerned. About five vessel-months of tagging effort will be available to United States research workers.

Consultations between scientists of the various research agencies and the Secretariat will be continued throughout the early part of 1961 in order to fill in details of research plans and arrange for maximum coordination of effort and coverage.

8. Implementation of the Provisions of Article III (1) (a) of the Convention (Abstention)

The North Pacific Convention provides that Japan and, in one case, Canada, shall refrain from fishing certain stocks of fish in the North Pacific, provided that the Contracting Parties which continue to fish these stocks continue to fulfill certain obligations. The stocks currently under abstention are defined in the Annex to the Convention[1]. Japan abstains from fishing salmon and halibut in the eastern Bering Sea and the eastern North Pacific Ocean. Japan also abstains from fishing herring off the Pacific coast of Canada and off the coast of the United States south of the entrance to the Strait of Juan de Fuca. Canada abstains from fishing salmon of United States origin in the eastern Bering Sea.

At its Sixth Annual Meeting (1959), in the course of its annual study of the qualifications for abstention of the stocks listed in the Annex to the Convention, the Commission determined that the herring stocks off the coast of Alaska south of the Alaskan Peninsula and east of the meridian passing through the extremity of the Alaskan Peninsula no longer met the requirements for continued abstention given in Article IV of the Convention. On this basis, the Commission re-

[1] The text of the Convention may be found in the Annual Report of the Commission for 1959.

commended to the Contracting Parties that the stocks of herring off the coast of Alaska be removed from the Annex to the Convention. On May 24, 1960, all of the Contracting Parties had signified their acceptance of the Commission's recommendation and, as of that date, Japan was no longer required to abstain from fishing herring off the coast of Alaska.

At its Seventh Annual Meeting, the Commission continued its studies of the qualifications of the stocks of fish which remain under abstention. For this purpose the Commission has established a special committee, known as the Ad Hoc Committee on Abstention. This Committee and its Scientific Sub-Committee are charged with receiving and reviewing the evidence submitted to the Commission by the various Contracting Parties with respect to the qualifications of the stocks under abstention. The Committee and its Sub-Committee conduct their business and report to the Commission on an *in camera* basis. However, as has been the case for the past several years, the Commission reported the results of its deliberations on the questions of abstention at a regular plenary session. The following is the verbatim text of the report on the subject of abstention determinations as read into the record of the Fourth Plenary Session of the Seventh Annual Meeting:

> "In accordance with the provisions of Article III (1) (a), the Committee studied for the purpose of determining annually whether the stocks of fish specified in the Annex (as amended May 24, 1960) continue to qualify for abstention. With respect to the stocks listed in Sections 1 (a), 1 (b), 1 (c) and 2 of the Annex no agreement was reached at this time, with respect to the conclusions from these studies, as to whether such stocks continue to qualify for abstention. The Committee therefore makes no recommendation at this time that the Commission make a determination that the stocks specified in Sections 1 (a), 1 (b), 1 (c) and 2 of the Annex no longer meet the conditions of Article IV."

In substance, the adoption of the above statement by the Commission means that Japan is required to continue to abstain from fishing salmon and halibut in the eastern Bering Sea and the eastern North Pacific Ocean and from fishing herring off the coast of Canada and off the coast of the United States south of the entrance to the Strait of Juan de Fuca. Canada is required to continue to abstain from fishing salmon of United States origin in the eastern Bering Sea.

The terms of the Convention require the Commission to review the qualifications of the stocks under abstention on an annual basis. Study of these questions will be continued.

During the course of its studies of the qualifications for abstention of the stocks listed in the Annex to the Convention, the Commission has received a large volume of scientific data and reports from the Contracting Parties and national sections. At its Sixth Annual Meeting (1959), the Commission approved a proposal to publish the scientific reports submitted in relation to the abstention determinations. Detailed recommendations on procedures to be followed in respect to publication of abstention documents were received from the Ad Hoc Committee on Abstention and adopted by the Commission during the Seventh Annual Meeting. These recommendations provide that the Commission shall publish documents on abstention for herring, halibut and salmon which have been submitted to the Commission under Article III (1) (a) prior to October 18, 1960. Publication is to proceed as rapidly as the mechanics of preparation, approval, printing, etc., can be carried out.

9. Implementation of Articles III (l) (c) (i) and III (1) (c) (ii) of the Convention, with Respect to King Crab

In 1954, at the request of the United States, the Commission undertook a study of the king crab (*Paralithodes camtschatica*) stocks of the eastern Bering Sea for the purpose of determining if joint conservation measures by Japan and the United States were required. Investigations of this type are provided for by the Convention under the terms of Article III (1) (c) (i) and III (1) (c) (ii). Investigations of the king crab stocks in the area began in 1955. Scientists from Japan and the United States have conducted separate but coordinated and cooperative investigations.

Evidence presented to the Commission by the scientists concerned with king crab investigations led to the conclusion that there was not any basis for recommending joint conservation measures with respect to this stock at the present time. However, it was apparent that the level of fishing effort was increasing significantly and that vessels from the U.S.S.R. had entered the fishery as well. It was therefore recommended that appropriate steps be taken by the Commission to obtain the pertinent statistics for the U.S.S.R. king crab fishery in the area.

Investigators for Japan and the United States will continue their studies of the king crab stocks in 1961, following research plans previously established. Information will be sought on abundance, growth, age, migration, mortality rates, environmental conditions and changes in meat quantity and quality. The increased fishing pressure on the stocks necessitates con-

tinuation of the studies of the biology of the species and of the effects of the fishery on the stocks.

10. Implementation of the General Provisions of the Convention

The Commission again reaffirmed a resolution adopted at its 1958 Annual Meeting and reaffirmed at its 1959 Annual Meeting, which reads as follows:

> "In view of the results of scientific investigations to date as contained in the reports of the Committee on Biology and Research and in accordance with the objective of conservation of fishery resources of the North Pacific Ocean, as expressed in the International Convention for the High Seas Fisheries of the North Pacific Ocean, the Ad Hoc Committee on the Protocol recommends that the International North Pacific Fisheries Commission respectfully recommend to the Governments of the Contracting Parties that full consideration be given to the conservation needs of these fisheries resources in the area of common concern when preparing fishing regulations for future operations."

In approving the adoption of the Report of the Committee on Biology and Research for 1960, a spokesman for the United States Section made the following statement for inclusion in the record:

> "The United States Section believes that the Commission's work will be greatly expedited if additional catch and biological data from the mothership fishery are available to the scientists for analysis.
>
> "We have drawn the attention of the appropriate committees to the desirability of the Commission having these additional data and we would now draw the attention of the Commission to the matter, expressing the earnest hope that the Japanese Section will find it possible to make the data available promptly."

Item 9 of the Agenda for the Plenary Sessions at the Seventh Annual Meeting was—"Consideration of the need for enlarging the scope of INPFC research." In relation to this agenda item, the Canadian Section of the Commission submitted a statement which, in summary, advocated the diversion of some research effort to give broader geographical coverage and greater emphasis to study of the fundamental facts of the life of salmon in the sea. The objective was to increase research in areas outside of the zone of intermingling of salmon from the two continents, where major efforts are concentrated at present. The Commission referred the agenda item, including the text of the Canadian Section's views, to the Committee on Biology and Research for consideration and report at the Eighth Annual Meeting (1961) of the Commission.

The Commission, on recommendation of the Committee on Biology and Research, accepted the Statistical Yearbook for 1959, as prepared by the Secretariat.

11. New Officers

The Commission elected the following officers for the term beginning with the close of the Seventh Annual Meeting and terminating with the close of the Eighth Annual Meeting in 1961:

Chairman of the Commission
—Mr. Iwao Fujita of Japan
Vice-Chairman of the Commission
—Mr. Edward W. Allen of the United States
Secretary of the Commission
—Mr. George R. Clark of Canada
Chairman of the Committee on Biology and Research
—Mr. James C. Cameron of Canada
Chairman of the Committee on Finance and Administration —Mr. Arnie J. Suomela of the United States.

Mr. George R. Clark of Canada will continue as chairman of the Ad Hoc Committee on Abstention and the Ad Hoc Committee on the Protocol until such time as these committees hold their next meetings.

12. Future Meetings

The Eighth Annual Meeting of the Commission will begin on November 6, 1961, in Tokyo, Japan. The period beginning on October 23, 1961, was designated as the period within which the time and place of advance committee meetings may be arranged by their respective chairmen in consultation with the Secretariat. If any meetings of sub-committees are judged to be desirable in advance of October 23, they may also be scheduled in the week prior to those set aside for the committee meetings, i.e., during the week of October 16, 1961.

13. Closing Statements

At the final plenary session of the Seventh Annual Meeting the Chairman of the Commission and spokesmen for the three national sections expressed their views regarding the progress and problems of the Commission. All speakers expressed appreciation of the hospitality shown by the host country, Canada, and gratification for the spirit of understanding and friendly cooperation that continues to develop among Commission members.

Commissioner Iwao Fujita of Japan spoke of the severity of the abstention provisions of the Convention and the consequent necessity for strict interpretation of their terms and an adequate demonstration of the qualification of the stocks. He expressed the view that the research in relation to the provisional line had not yet reached a stage where the line could either be confirmed in its present position or relocated. Mr. Fujita stated that, although Japan's only obligation was to abstain from fishing certain stocks east of the present provisional line, Japan was deeply interested in the conservation of salmon stocks and has therefore agreed to a resolution by the Commission on the conservation of stocks.

Commissioner Milton E. Brooding, spokesman for the United States Section of the Commission, complimented the Commission on its achievements in research. The United States Section felt that it was clear that the salmon and halibut stocks of North American origin covered by the Convention are being fully utilized and continue to qualify for abstention. It was felt that research in relation to the Protocol had shown that sockeye salmon of Western Alaska origin predominate from the Alaskan coast westward to 180° Longitude and make up a substantial proportion of the sockeye salmon for at least another 10° to the west. In view of these facts and the unsettled nature of the Protocol questions it was felt that Japan should exercise the utmost restraint in her high seas salmon fishing operations in the crucial area west of the provisional line.

Commissioner Roger T. Hager, on behalf of the Canadian National Section, expressed encouragement at the advancements made toward the ultimate objectives of the Convention. Scientific achievements were particularly outstanding. Arrangements for publication of scientific papers on various phases of the research program, preparation of joint reports on research results and the publication of the scientific papers related to stocks under abstention also were noted with satisfaction. Mr. Hager spoke of the difficulties involved in trying to provide irrefutable evidence of a concrete nature when dealing with the biological aspects of the abstention problems. Canada constantly reviews her abstention cases in order to present the best evidence possible.

The Chairman of the Commission, Mr. George R. Clark of Canada, in closing the Seventh Annual Meeting, congratulated the Commission on its stability and progress. He noted that the Report of the Committee on Biology and Research for 1960 was of major significance and that most valuable scientific data were being accumulated, to the benefit of the three countries. The Chairman expressed gratification to the Secretariat for its work and expressed the hope that the observers from the international organizations and the U.S.S.R. had found the deliberations of the Commission to be of interest and value.

APPENDIX I

LIST OF PARTICIPANTS

OFFICERS OF THE MEETING

Chairman	Vice-Chairman	Secretary
George R. Clark, Canada	Iwao Fujita, Japan	Edward W. Allen, United States

CANADA

Commissioners

George R. Clark, Ottawa, Canada

John M. Buchanan, Vancouver, B. C.

James C. Cameron, Madeira Park, B. C.

Roger T. Hager, Vancouver, B. C.

Advisors and Experts

A. W. H. Needler
R. E. Foerster
F. Neave
J. I. Manzer
H. Godfrey
W. M. Sprules
L. Margolis
M. P. Shepard
T. H. Bilton
K. S. Ketchen
F. H. C. Taylor
J. P. Tully
A. J. Dodimead
L. F. Giovando
W. E. Ricker
R. R. Parker
C. E. Chatillon
W. R. Hourston

JAPAN

Commissioners

Iwao Fujita, Tokyo, Japan

Kenjiro Nishimura, Tokyo, Japan

Yoshimitsu Ando, Tokyo, Japan

Kenkichi Nakabe, Tokyo, Japan

Advisors and Experts

M. Fujisaki
M. Tanabe
K. Kawakami
Y. Uchimura
C. Yamada
T. Isogai
H. Aikawa
Y. Fukuda
T. Matsushita
T. Ishida
K. Yonezawa
H. Tominaga
T. Yamamoto
K. Taguchi
S. Mizota

UNITED STATES

Commissioners

Edward W. Allen, Seattle, Washington

Milton E. Brooding, San Francisco, California

John H. Clawson, Anchorage, Alaska

Arnie J. Suomela, Washington, D. C.

Advisors and Experts

R. Anas
C. E. Atkinson
S. Blow
R. L. Burgner
D. G. Chapman
F. C. Cleaver
F. Fukuhara
M. G. Hanavan
G. Y. Harry
A. C. Hartt
W. C. Herrington
S. J. Hutchinson
R. Lander
D. P. Loker
E. Mains
J. L. McHugh
D. L. McKernan
T. Miyahara
H. Raynor
G. Ridgway
H. A. Rietze
W. F. Royce
R. P. Silliman
R. J. Tepper

C. DiCostanzo
F. Favorite
R. A. Fredin
W. Kirkness
T. S. W. Koo
J. LaLanne
K. Mosher
W. H. Noerenberg
D. Paddock
W. M. Terry
W. F. Thompson
W. G. Van Campen
D. Worlund

Advisory Committee

C. L. Anderson
W. C. Arnold
C. R. Carry
R. S. Croker
H. B. Friele
DeWitt Gilbert
G. Johansen
R. C. Kallenberg
A. E. Kemmerich
H. E. Lokken
M. Moore
A. Owen
T. F. Sandoz
R. W. Schoning
J. W. Smith
P. Tandstad
L. Wakefield
J. Waugh

Secretary to the United States Section
C. J. Burner

OBSERVERS

International Pacific Salmon Fisheries Commission
A. J. Whitmore
L. A. Royal
K. Henry
E. H. Vernon

International Pacific Halibut Commission
H. A. Dunlop
F. Heward Bell
R. J. Myhre
M. Southward
W. H. Hardman

Inter-American Tropical Tuna Commission
J. L. McHugh

International Commission for the Northwest Atlantic Fisheries
A. J. Suomela

Union of Soviet Socialist Republics
Boris G. Kulikov
Lev S. Bogdanov

SECRETARIAT

Permanent
R. I. Jackson
H. Kasahara
L. M. Kissack

Temporary
N. Tokaji
K. Hirai
S. Tanaka
M. Hunter
C. Landie
J. Harris
B. Woodland

MEMBERSHIP OF COMMITTEES

1. Standing Committee on Finance and Administration

CANADA
Commissioner-member — Roger T. Hager
Commissioner-advisors — John M. Buchanan, George R. Clark

JAPAN
Commissioner-members — Kenjiro Nishimura, Iwao Fujita
Advisors — Kunio Yonezawa, Chusei Yamada

UNITED STATES
Commissioner-member — Arnie J. Suomela
Advisor-member — Donald P. Loker
Advisor — W. M. Terry

SECRETARIAT
Ex-officio members — Roy I. Jackson, Hiroshi Kasahara

2. Standing Committee on Biology and Research

CANADA

Commissioner-member	James C. Cameron
Advisor-members	A. W. H. Needler
	W. M. Sprules

JAPAN

Commissioner-members	Kenkichi Nakabe
	Iwao Fujita
Advisor-members	Hiroaki Aikawa
	Tomonari Matsushita

UNITED STATES

Commissioner-member	John H. Clawson
Advisor-members	D. L. McKernan
	W. F. Royce

SECRETARIAT

Ex-officio members	Roy I. Jackson
	Hiroshi Kasahara

3. Ad Hoc Committee on Abstention

CANADA

Commissioner-member	George R. Clark
Commissioner-advisor	James C. Cameron
Advisors	A. W. H. Needler
	W. M. Sprules
	L. Margolis
	M. P. Shepard
	C. E. Chatillon
	K. S. Ketchen
	F. H. C. Taylor
	W. E. Ricker

JAPAN

Commissioner-member	Iwao Fujita	
Commissioner-advisors	Kenjiro Nishimura	
	Yoshimitsu Ando	
	Kenkichi Nakabe	
Advisors	M. Fujisaki	H. Aikawa
	M. Tanabe	Y. Fukuda
	K. Kawakami	T. Matsushita
	Y. Uchimura	T. Ishida
	C. Yamada	K. Yonezawa
	T. Isogai	H. Tominaga
		T. Yamamoto
		K. Taguchi
		S. Mizota

UNITED STATES

Commissioner-member	Edward W. Allen	
Commissioner-advisors	Milton E. Brooding	
	Arnie J. Suomela	
Advisors	C. L. Anderson	H. E. Lokken
	C. E. Atkinson	J. L. McHugh
	C. J. Burner	D. L. McKernan
	D. Chapman	W. F. Royce
	R. A. Fredin	R. J. Tepper
	W. C. Herrington	W. M. Terry
	R. C. Kallenberg	W. G. Van Campen

4. Ad Hoc Committee on the Protocol

CANADA

Commissioner-member	George R. Clark
Commissioner-advisor	John M. Buchanan
Advisors	A. W. H. Needler
	W. M. Sprules
	L. Margolis
	M. P. Shepard
	C. E. Chatillon
	W. E. Ricker

JAPAN

Commissioner-member	Kenjiro Nishimura	
Commissioner-advisors	Iwao Fujita	
	Yoshimitsu Ando	
	Kenkichi Nakabe	
Advisors	M. Fujisaki	H. Aikawa
	M. Tanabe	Y. Fukuda
	K. Kawakami	T. Matsushita
	Y. Uchimura	T. Ishida
	C. Yamada	K. Yonezawa
	T. Isogai	H. Tominaga
		T. Yamamoto
		K. Taguchi
		S. Mizota

UNITED STATES

Commissioner-member	Milton E. Brooding	
Commissioner-advisor	Edward W. Allen	
Advisors	C. L. Anderson	D. L. McKernan
	C. J. Burner	W. F. Royce
	F. C. Cleaver	W. M. Terry
	W. C. Herrington	W. G. Van Campen
	J. L. McHugh	

APPENDIX II

AGENDA

as adopted at the

SEVENTH ANNUAL MEETING—1960

Vancouver, British Columbia, November 7 to 11, 1960

1. Addresses and introductions
2. Adoption of agenda
3. Report on delegation memberships
4. Meeting procedures
   - (a) Attendance at meetings
   - (b) Schedule of sessions
   - (c) Press policy
   - (d) Minutes
5. Report of the Chairman
6. Report of the Secretary
7. Submission of reports by the Secretariat
8. Consideration of matters of research
   - (a) Research phase of the Protocol to the Convention
   - (b) Preparation of joint reports on research
   - (c) Long-range research plans
   - (d) King crab research (Article III (1) (c) (i))
   - (e) Statistics (Article III (1) (e))
   - (f) Other matters
9. Consideration of the need for enlarging the scope of INPFC research
10. Consideration of salmon problems in high seas areas of intermingling
11. Implementation of the Protocol
12. Implementation of Article III (1) (a) of the Convention with respect to the stocks listed in the Annex
    - (a) Halibut (Annex paragraph 1 (a))
    - (b) Herring (Annex paragraph 1 (b))
    - (c) Salmon of the northeastern North Pacific (Annex paragraph 1 (c))
    - (d) Salmon of the eastern Bering Sea (Annex paragraph 2)
13. Publication of abstention documents
14. Implementation of Article III (1) (c) (ii) with respect to king crab
15. Consideration of administrative and fiscal matters
    - (a) Accounts and audit
    - (b) Budget for fiscal year beginning July 1, 1961
    - (c) Budget forecast for fiscal year beginning July 1, 1962
    - (d) Administrative report for 1960
    - (e) Comments on the form and nature of the reports submitted by Canada and the United States under Articles III (1) (c) (iii) and X (2) of the Convention
    - (f) Schedule of future meetings
    - (g) Other matters
16. Election of officers
17. Other business
18. Closing remarks

II. ADMINISTRATIVE REPORT FOR 1960

by the Executive Director

Roy I. Jackson

1. Purpose of the Report

This report contains information on fiscal and administrative matters and a record of the activities of the Secretariat of the International North Pacific Fisheries Commission for the period beginning with the close of the Sixth Annual Meeting of the Commission on November 7, 1959, and ending on October 17, 1960, when sessions prior to the Seventh Annual Meeting began.

2. Officers and Staff

The Commission annually elects a Chairman, Vice-Chairman and Secretary. Representation in each of the offices rotates between Commissioners from the three member countries. Officers of the Commission and its standing committees begin their terms upon adjournment of an annual meeting and continue until adjournment of the subsequent annual meeting. Officers of the Commission for the term which began at the adjournemt of the 1959 Annual Meeting have been: Chairman, Mr. George R. Clark of Canada; Vice-Chairman, Mr. Iwao Fujita of Japan; Secretary, Mr. Edward W. Allen of the United States.

For the same term, the Chairman of the Standing Committee on Biology and Research has been Mr. John H. Clawson of the United States. The Chairman of the Standing Committee on Finance and Administration has been Mr. Kenjiro Nishimura of Japan.

There were no changes in permanent personnel in the Commission's Secretariat.

3. Changes in Membership of the National Sections

Mr. Koichiro Kobayashi of Japan resigned from the Commission on August 12, 1960, and was replaced by Mr. Kenkichi Nakabe on the same date.

Mr. Haruki Mori resigned from the Commission on September 22, 1960, and was replaced by Mr. Yoshimitsu Ando on the same date. Mr. Ando also succeeded Mr. Mori as the official correspondent of the Japanese National Section of the Commission.

There were no changes in the national sections of Canada or the United States during the period covered by this report.

4. Votes

The Rules of Procedure of the Commission provide that it may vote by correspondence on matters with which it is concerned, when this is deemed expedient. Decisions made by the Commission in the interval between the 1959 and the 1960 Annual Meetings and the dates on which they were announced or otherwise took effect are as follows:

a. The Commission approved the draft summary minutes of the Third Plenary Session of the 1959 Annual Meeting. Approval was announced in Circular Letter No. 114, dated January 15, 1960.

b. The Commission approved the draft summary minutes of an *in camera* session which it held on November 7, 1959. Approval was announced in Circular Letter No. 114, dated January 15, 1960.

c. The Commission approved wording to implement the amendment of the Annex of the Convention with respect to Alaska herring. The amendment to the Annex had been recommended by the Commission at the Third Plenary Session of the Sixth Annual Meeting, on November 7, 1959. Approval of the wording to implement amendment of the Annex was announced in Circular Letter No. 123, dated May 9, 1960. (On May 24, 1960, all Contracting Parties accepted the Commission's recommendation for wording to amend the Annex and Alaskan herring were removed from abstention on that date.)

d. The Commission gave approval for publication of a draft of its annual report for 1959. Approval was announced in Circular Letter No. 136, dated August 26, 1960.

e. The Commission approved issuance of invitations to the following to be represented by ob-

servers at the 1960 Annual Meeting of the Commission and its standing committees:

Food and Agriculture Organization of the United Nations
International Pacific Halibut Commission
International Pacific Salmon Fisheries Commission
International Commission for the Northwest Atlantic Fisheries
Inter-American Tropical Tuna Commission
Union of Soviet Socialist Republics.

f. A tentative agenda for the plenary sessions of the Seventh Annual Meeting was transmitted to all national sections on July 26, 1960. Views expressed thereon were incorporated in a provisional agenda which was transmitted to the Commission on September 13, 1960, in Circular Letter No. 139.

g. The Commission gave its approval to the "Second Report of the Editorial Sub-Committee of the Ad Hoc Committee on Abstention." Approval was announced in Circular Letter No. 141, dated September 23, 1960. The report in question releases from confidential status and establishes order for publication of all reports submitted to that date by the Contracting Parties in relation to herring, halibut and salmon abstention.

h. The Commission gave approval for publication of INPFC Bulletin No. 3, containing scientific papers on phases of the Commission's research program. Approval was completed on October 12, 1960, and announced on the same day in Circular Letter No. 143.

5. Removal of Alaskan Herring from Abstention

At its Sixth Annual Meeting the Commission recommended to the Contracting Parties that the herring stocks off the coast of Alaska south of the Alaskan Peninsula and east of the meridian passing through the extremity of the Alaskan Peninsula be removed from the Annex to the Convention. The Contracting Parties agreed with the Commission's recommendation; however, the Government of the United States expressed the view that the action recommended by the Commission would not become effective until all Contracting Parties had accepted appropriate language for amendment to the Annex to the Convention. The Commission then recommended language to amend the Annex, which was accepted by all Contracting Parties. The requirement for abstention by Japan from fishing herring off the coast of Alaska therefore terminated on May 24, 1960.

6. Reaffirmation of Conservation Resolution

At its 1958 Annual Meeting, the Commission adopted a resolution asking the Contracting Parties to give full consideration to the conservation needs of fisheries resources in the area of common concern when preparing regulations for future operations (Section 3, Minutes of the Third Plenary Session, 1958 Annual Meeting). This resolution was reaffirmed by the Commission at the Third Plenary Session of its 1959 Annual Meeting. The Secretariat drew the reaffirmation of the resolution to the attention of the Contracting Parties, all of which replied to the effect that they would continue to give full consideration to the conservation needs of the fisheries resources with which the resolution was concerned.

7. Reports from Contracting Parties

There are two articles in the Convention which require the Contracting Parties to submit reports through the Commission in relation to stocks of fish which another Party is abstaining from fishing. Article III (1) (c) (iii) of the Convention requires regular reports on conservation measures adopted from time to time with regard to the stocks of fish specified in the Annex. Article X (2) of the Convention requires the Contracting Parties concerned to report periodically through the Commission to the Contracting Party which has agreed to abstain from the exploitation of certain stocks of fish on the enforcement conditions for their own conservation measures with respect to such stocks. Each year the United States and Canada have reported through the Commission to the other Contracting Parties under the requirements of these Treaty articles. The most recent report by Canada under these articles was received by the Commission and transmitted to the other Contracting Parties on September 27, 1960. The report from the United States under these articles was received by the Commission and transmitted to the other Contracting Parties on October 5, 1960.

The Secretariat is now in the process of evaluating these reports as to their form and nature and reporting on its evaluations to the Commission. Such evaluations have been submitted by the Secretariat each year.

8. Accounts and Audit

The report of the Commission's auditors', Peat,

Marwick, Mitchell & Company, for the fiscal year ended June 30, 1960, is attached to this report as Appendix I.

Each Contracting Party contributed $15,913, Canadian funds, toward the operating expenses of the Commission, making a total of $47,739 in contributions. In addition, interest earned on the working capital fund, totalling $102.88, was credited to general funds in accordance with Financial Regulation 7.1. Total of funds available was thus $47,841.88. Of this amount, the sum of $3,444.84 was held over into the 1960–61 fiscal period as a reserve for accounts payable, accrued expenses and legal obligations from the 1959–60 period. On this basis there was no surplus from 1959–60 appropriations.

A financial bond in favour of the Commission, in the amount of $25,000 was continued on all permanent staff members. The bond is in the hands of the Deputy Minister of Fisheries for Canada for safekeeping.

9. Working Capital Fund

The Commission has a working capital fund amounting to $5,864.75, Canadian funds, which was established by equal contributions from the three Contracting Parties. No use was made of the working capital fund during the 1959–60 fiscal period.

10. Interim Meetings

Since the Sixth Annual Meeting recessed, several groups have carried on the work of the Commission at interim meetings which were held in Tokyo. Although the work of these groups will be reported in detail through their parent committees, brief mention of their activities is made here.

A working party of scientists from the three countries met in Tokyo beginning on May 25 for the purpose of preparing a joint report on the distribution of salmon on the high seas. Their work in Japan continued until July 20, 1960.

In the period from June 6 to June 17, three other groups of scientists met in Tokyo. A sub-committee of the Committee on Biology and Research met to study long-range research plans in connection with the scientific problems posed by the Protocol. The editorial referees of the Committee on Biology and Research met to select reports for publication in the Commission's bulletin series, to take further steps towards production of comprehensive joint reports on the Commission's research and to expedite the publication of additional research material.

The third group was the editorial sub-committee of the Ad Hoc Committee on Abstention, which met to select and arrange abstention documents for publication in the Commission's bulletin series. As a result of their recommendations, which have been formally approved by the Commission, all of the scientific materials on abstention submitted to the Commission have been released from their confidential status and will be published as soon as the Secretariat can make the necessary arrangements and prepare explanatory and prefactory material to provide a context for the reports.

Oceanographers from the three countries have been working by correspondence on preliminary steps toward a joint report on the oceanography of the sub-Arctic region of the North Pacific Ocean. The group is approaching the stage of agreement on a table of contents for the report and assignment of portions of the report to the authorship of particular individuals.

11. Staff Activities

The Secretariat of the Commission consists of three permanently-employed persons, a Director, Assistant Director and Secretary, and such short term temporary employees as are required and for whose employment funds are available. The functions of the Secretariat include arrangements for meetings, assisting in the mechanics of conduct of meetings, preparation of agendas, budgets, commentaries, reports and other documents for use at meetings. Correspondence is conducted with Commissioners, scientists, government agencies, and others in connection with the research program and other basic Treaty obligations. The Secretariat acts as a clearing house for the exchange of information, samples and scientific, technical and administrative information.

During the past year, the Secretariat has assembled and/or prepared a draft of the annual report of the Commission for 1959. The English-language version is at present in the hands of the printers. Unfortunately, due to delays in approval of the draft manuscript, the English version will not be available at the time of this annual meeting. Both the English and Japanese-language versions of the annual report for 1959 will be printed in Japan.

As usual, the Secretariat has compiled and reproduced a statistical yearbook. The volume for 1959 contains catch statistics for the important fisheries of joint interest in the Convention area. Data for the compilation were provided by the statistical agencies of the member countries. In addition, as a special assignment, the Secretariat is compiling a

volume of historical statistics on salmon. This volume, when completed, will contain information on the catches of salmon throughout the North Pacific area from the year 1900 to the present. This project was assigned to the Secretariat at its own suggestion, in order to bring together into one volume information which will be of assistance to those producing comprehensive joint reports on research for the Commission.

As a background paper for the Tokyo interim meeting on long-range research planning, the Secretariat prepared an assessment of the present status of the INPFC research program.

After the 1959 Annual Meeting, the Secretariat compiled and reproduced the usual volume of proceedings of the annual meeting. This volume has also been prepared in the Japanese language, with the assistance of the Japanese National Section, at the expense of the Secretariat. This arrangement for translation applies to the majority of documents and papers produced by the Commission. The bound volumes of proceedings for the Ad Hoc Committee on Abstention, the Ad Hoc Committee on the Protocol and the *in camera* sessions of the Commission were also brought up to date.

A draft manuscript of Bulletin No. 3 of the Commission was prepared and forwarded to the members of the Commission for their approval for publication.

The Secretariat continues to urge that the results of the Commission's extensive and unique research program be reported in published form as rapidly and completely as possible. Funds for this purpose have been provided by the Commission.

Quarterly newsletters have been continued during the year under review. Representatives of the various organizations conducting research under the Commission's program have been most generous in providing information for use in the newsletter.

The Director visited Commissioners and others concerned with the Commission's activities in Ottawa, Washington and San Francisco on two occasions since the last annual meeting. In addition, the Director and Assistant Director both took part in the interim meetings in Tokyo in June and took advantage of the opportunity to discuss Commission affairs with members of the Japanese National Section.

In late August, the Director travelled extensively over the Fraser and Skeena watersheds in British Columbia in the company of the Chairman of the Fisheries Research Board of Canada, Dr. J. L. Kask, and the Director of the Pacific Biological Station, Dr. A. W. H. Needler. The purpose of the trip was to visit the field research facilities for salmon investigations of the International Pacific Salmon Fisheries Commission and the Fisheries Research Board of Canada. Arrangements made by these organizations were excellent and the trip was highly informative and brought us abreast of research and progress in salmon management in British Columbia.

Frequent visits have been made by staff members to the Biological Laboratory of the Bureau of Commercial Fisheries in Seattle and the Laboratory of the Fisheries Research Board in Nanaimo. Members of the Secretariat attempt to keep posted on progress in Commission research and to keep abreast of problems as they arise.

Dr. Kasahara, the Assistant Director of the Commission, was honoured by appointment to the H. R. MacMillan lectureship in fisheries at the University of British Columbia for 1960. Dr. Kasahara gave a series of lectures on fisheries resources of the North Pacific Ocean to graduate students, faculty members and guests. He also participated in a symposium on fluctuations in pink salmon populations which was held by the Fisheries Institute of the University of British Columbia, beginning on October 14, 1960.

12. Appendices

The following reports and documents are herewith submitted to the Commission with this Administrative Report for 1960. It is recommended that they be received by the Commission and referred to the appropriate committees for consideration and recommendation as to further action.

1. Report of the Commission's auditors for the fiscal year ended June 30, 1960 (INPFC Document 383).
2. Budget estimate for 1961–62 and forecast for 1962–63 (INPFC Document 380).
3. Statistical Yearbook, 1959.
4. Comments on the form and nature of the reports submitted in 1960 under Articles III (1) (c) (iii) and X (2) of the Convention (INPFC Document 389).

APPENDIX I

PEAT, MARWICK, MITCHELL & CO.

Chartered Accountants

410 Seymour Street
Vancouver 2
B.C.

AUDITORS' REPORT TO THE COMMISSION

We have examined the balance sheet of the International North Pacific Fisheries Commission as of June 30, 1960 and the statements of income and expenditure and receipts and disbursements for the year ended on that date and have obtained all the information and explanations we have required. Our examination included a general review of the accounting procedures and such tests of accounting records and other supporting evidence as we considered necessary in the circumstances.

In our opinion, and according to the best of our information and the explanations given to us and as shown by the books of the Commission, the accompanying balance sheet and statements of income and expenditure and receipts and disbursements are properly drawn up so as to exhibit a true and correct view of the state of the affairs of the Commission at June 30, 1960 and the results of its operations for the year ended on that date, in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Peat, Marwick, Mitchell & Co.
Chartered Accountants

Vancouver, B. C.
July 26, 1960

STATEMENT OF ASSETS AND LIABILITIES
JUNE 30, 1960

Assets

General funds:		
Cash in bank		$3,019.84
Deposit with United Air Lines		425.00
		3,444.84
Working capital fund:		
Cash in bank		5,864.75
Equipment, at cost	$9,147.68	
Less accumulated depreciation	3,297.81	5,849.87
		$15,159.46

Liabilities

General funds:		
Accounts payable and accrued expenses		$3,444.84
Advances from contracting parties for working capital fund		5,864.75
Amount equivalent to expenditure on equipment less depreciation, per contra:		
Amount at June 30, 1959	$8,586.18	
Additions during the year	561.50	
	9,147.68	

Deduct:			
Depreciation provided in previous years	$2,383.04		
Depreciation in current year	914.77	3,297.81	5,849.87
			$15,159.46

STATEMENT OF INCOME AND EXPENDITURE
Year ended June 30, 1960

Income:		
Contributions from contracting parties		$47,739.00
Interest earned on working capital fund bank account		102.88
		47,841.88
Expenditure:		
Personal services	$29,064.68	
Travel	6,675.73	
Transportation of things	218.87	
Communications	1,256.31	
Other contractual services	5,717.93	
Supplies	1,800.34	
Equipment	561.50	
Cost of annual meeting	2,546.52	47,841.88
		$ —

STATUS OF APPROPRIATIONS

	Budget Appropriations	Appropriations as modified by transfers	Expenditures
Personal Services	$29,299.00	29,064.68	29,064.68
Travel	6,500.00	6,675.73	6,675.73
Transportation of things	300.00	218.87	218.87
Communications	1,200.00	1,256.31	1,256.31
Other contractual services	6,792.88	5,717.93	5,717.93
Supplies	1,500.00	1,800.34	1,800.34
Equipment	1,000.00	561.50	561.50
Cost of annual meeting	1,250.00	2,546.52	2,546.52
	$47,841.88	47,841.88	47,841.88

Note:

The budget appropriation for "other contractual services" has been adjusted to include $102.88 received in interest on the working capital fund.

STATEMENT OF RECEIPTS AND DISBURSEMENTS
Year ended June 30, 1960

Receipts:		
Contributions from contracting parties		$47,739.00
Interest on working capital fund bank account		102.88
		47,841.88
Disbursements:		
Personal services	$29,064.68	
Travel	7,583.91	
Transportation of things	218.87	
Communications	1,256.31	
Other contractual services	4,370.55	
Supplies	1,800.34	
Equipment	561.50	
Cost of annual meeting	2,546.52	47,402.68
Excess of receipts over disbursements represented by increase in bank accounts:		
Balance June 30, 1960	8,884.59	
Balance June 30, 1959	8,445.39	
		$439.20

III. THE RESEARCH PROGRAM

A. PROGRESS IN 1960 IN CANADIAN RESEARCH ON PROBLEMS RAISED BY THE PROTOCOL

As part of the Commission's program of research on problems raised by the Protocol Canada, in 1960, carried out: (1) studies of the vertical distribution of salmon, (2) tagging of salmon in the eastern Gulf of Alaska, (3) studies of high-seas distribution of sockeye from Rivers and Smith Inlets, British Columbia, as recognized by their scales, (4) study of sockeye salmon parasites to distinguish stocks and show their distribution on the high seas, (5) study of chum salmon scales for the same purpose, and (6) extensive observations and analyses of oceanographic conditions and circulation in the northeastern Pacific.

1. Vertical Distribution of Salmon in the Western Gulf of Alaska

In 1960, further investigation of the vertical distribution of salmon in the high seas was carried out by the chartered vessel *Fort Ross* which left Nanaimo on May 6 and returned on July 25. As much as possible of this period was spent in fishing and making related observations in an area about 100 to 150 miles south of Kodiak Island, in the northwest part of the Gulf of Alaska (Lat. 55° N., Long. 150° to 155° W.). This location was selected because previous experience had shown that salmon were relatively numerous in these waters and because it was thought that conditions would be favourable for observing relationships between salmon distribution and the temperature structure of the ocean.

The essential part of the gear consisted of a nylon gill-net of 4-1/2″ mesh, 40 feet deep, with an initial length of 400 fathoms. This was suspended from buoys by drop-lines. By using drop-lines of different length, the net could be set at any one of five levels which collectively covered a depth range of 200 feet from the surface. In conjunction with this adjustable net, a conventional surface gill-net was used. This was of 4-1/2″ mesh throughout, 20 feet in depth, with an initial length of 300 fathoms. Due to loss or damage incurred during operations, both nets were subsequently shortened, as shown in Table I.

Catches and associated data are summarized in Table I. The depth net was set on 29 occasions and yielded a total of 435 salmon (276 sockeye, 132 chum, 27 pink). The surface net was set on 26 occasions and yielded 711 salmon (497 sockeye, 131 chum, 70 pink, 3 coho). Since the surface net differed from the adjustable net in length, depth, and possibly in tension and catching efficiency, it served mainly as a general indicator of the availability of fish at the surface during the periods when the depth net was operated at the various levels. Since the depth net was set at the surface as well as at deeper levels the catches from this gear alone are considered in Figures 1 and 2. These figures show the percentages of sockeye and chum salmon caught at each level after weighting for the number of sets made, the amount of gear set and the number of hours fished.

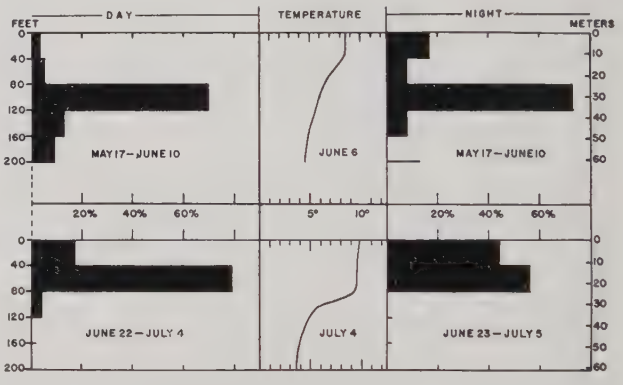


Figure 1. Percentage of sockeye salmon caught at each depth fished (weighted for fishing effort).

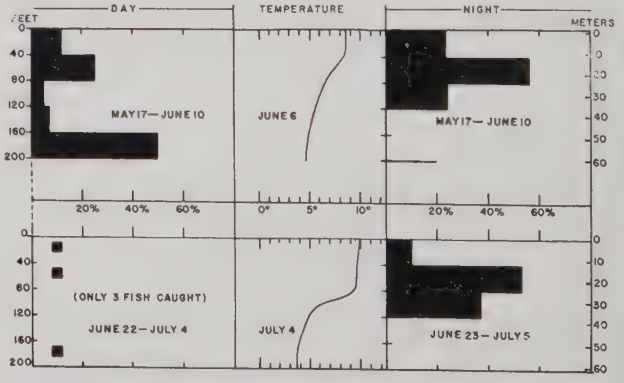


Figure 2. Percentage of chum salmon caught at each depth fished (weighted for fishing effort).

Sockeye salmon. Daytime fishing during the early period showed sockeye to be distributed throughout the

TABLE I. Salmon catches by MV *Fort Ross*, 1960.

		Surface Net						Depth Net					
Date	Fishing time (hr.)	Length of net (fath.)	Sockeye	Chum	Pink	Coho	Total	Fishing depth (feet)	Length of net (fath.)	Sockeye	Chum	Pink	Total
Day Sets													
17.5[1]	6.25	300	19	6	0	0	25	0–40	400	10	4	0	14
18.5[1]	5.00	300	4	2	0	0	6	40–80	400	3	6	0	9
19.5[1]	5.75	300	6	1	0	0	7			— Net lost —			
2.6	6.00	300	94	1	0	0	95	80–120	200	76	5	0	81
4.6	9.00	300	19	2	0	0	21	120–160	200	24	2	0	26
5.6	6.00	250	10	1	0	0	11	160–200	200	9	11	0	20
6.6	7.50			— Not set —				0–40	200	5	3	0	8
7.6	6.00	250	4	1	0	0	5	40–80	200	12	4	0	16
22.6	8.00	250	3	0	0	0	3	160–200	200	0	1	0	1
23.6	6.00			— Not set —				0–40	200	4	1	0	5
24.6	8.50	250	8	6	0	0	14	40–80	200	25	1	0	26
1.7	6.50	250	8	7	0	0	15	80–120	200	1	0	2	3
2.7	6.50	250	8	3	0	0	11	120–160	200	0	0	0	0
4.7	7.00	250	2	9	0	0	11	160–200	200	0	0	0	0
		Total	185	39	0	0	224			169	38	2	209
Night Sets													
18.5[1]	11.00	300	14	5	0	0	19	0–40	400	15	2	1	18
19.5[1]	9.00	300	13	3	0	0	16	40–80	400	2	26	0	28
3.6	8.50	300	54	1	0	0	55	80–120	200	38	3	0	41
4.6	9.00	300	52	4	0	0	56	120–160	200	1	0	0	1
5.6	9.00	250	29	5	0	0	34	160 200	200	0	0	0	0
6.6	11.00			— Not set —				0–40	200	5	11	0	16
7.6	9.50	250	19	11	0	0	30	40 80	200	4	13	0	17
8.6	8.50	250	19	12	0	1	32	80–120	200	4	6	0	10
10.6	10.00	250	10	3	0	0	13	120–160	200	5	0	0	5
23.6	9.00	250	4	10	4	0	18	160–200	200	0	0	0	0
24.6	9.00			— Not set —				0–40	200	11	2	0	13
1.7	9.50	250	21	3	0	0	24	40–80	200	15	12	15	42
2.7	11.00	250	29	18	43	1	91	80–120	200	0	10	7	17
4.7	9.00	250	17	4	16	0	37	120–160	200	0	0	0	0
5.7	7.50	250	23	5	1	0	29	160–200	200	0	0	0	0
13.7	10.50	300	8	18	6	1	33	0–40[2]	200	8	8	2	18
		Total	312	102	70	3	487			108	93	25	226

[1] Position: Lat. 55°N, Long. 155°W. All other sets made at Lat. 55°N, Long. 152°W.

[2] 3-1/4″ mesh used (depth net only). All other sets made with 4-1/2″ mesh.

vertical range which was investigated. The large preponderance of fish at the 80- to 120-foot level may be exaggerated, since the surface gill-net showed that sockeye were also plentiful at the surface at the time when these fish were caught (Table I). Nevertheless it is concluded that only a small fraction of the sockeye population was available to surface gill-nets fishing by day at this time of year, the rest of the population being distributed at depths downward to more than 160 feet.

Night-time fishing during the same period indicated some upward shift, inasmuch as no fish were caught below 160 feet and relatively greater numbers than in daytime fishing were taken in the top 80 feet. Many fish, however, were still present at the same levels as in the daytime.

In the later fishing period (June 22 to July 5) only one sockeye was caught below 80 feet. Again there was an indication of a shift to the surface by some fish at night, but again there were many fish present at the same level as in the daytime. This level, however, was not so deep as in the early part of the season. Except at the 0- to 40-foot level, catches of sockeye were consistently greater in daytime than in night-time fishing.

The temperature within the vertical interval in which fishing was carried out (over the whole fishing

season and at all levels) varied from about 4.5°C. to 10°C. Since the species has been found elsewhere in temperatures as low as 3°C. and as high as 15°C. (in surface fishing), it is obvious that no absolute limits were imposed by this factor. Actually, bathythermograph records showed that 4° water prevailed down to depths of at least 750 feet. Nevertheless, the catch records indicate that during the night-time of the earlier period of fishing and during both day and night of the later period, sockeye were confined to a much shallower zone. It is noteworthy, however, that whereas the wide vertical range observed in the daytime during the first period coincided with a condition of small temperature change with depth, the limit of downward distribution in the later period was accurately represented by the thermocline which had then developed (Fig. 1). This is in agreement with data obtained in 1959.

The age-composition of sockeye caught by the depth net was as follows:

Age		4_1	4_2	5_2	5_3	6_3	Unknown
May 17 to June 10, no.		1	114	40	27	21	9
	%	–	54	19	13	10	4
June 22 to July 5, no.		0	36	7	9	0	4
	%	0	64	12	16	0	7

While 4_2 fish predominated in both periods, the figures indicate that the 6_3 and some of the 5_2 fish had moved out of the area by late June. No third-year fish were taken, probably because of the relatively large mesh-size used.

Maturing and immature fish in these catches were segregated by weighing the gonads and applying the criteria proposed by Godfrey (1959). According to this classification, 97% of all fish caught during the earlier period were maturing, whereas only 49% in the later period were in this condition.

No consistent differences in vertical distribution were found between maturing and immature fish or between the various age groups.

Chum salmon. Early season daytime fishing showed that chum, like sockeye, were present at all depths investigated (Fig. 2). There was also evidence of a withdrawal of fish from the deepest level and a greater concentration at the surface during the night. Many fish were still present, however, at intermediate levels.

In the later period, chums did not show the marked upward shift which characterized the distribution of sockeye. Daytime sets, while only yielding 3 fish, were sufficient to show the presence of the species down to the 160- to 200-foot level. Night catches were consistent with the previously noted tendency of both chum and sockeye to make a moderate upward shift at this time.

In contrast with the sockeye, it was noted that chum catches were consistently greater in night sets than in daytime sets (except at levels where the species appeared to be absent at night). This suggests a difference between the two species in the rhythm of diurnal activity and perhaps in time of feeding.

Since chums are known to tolerate temperatures from 1° or 2°C. to 15°C., it is even more evident than in the case of the sockeye that the observed depth distribution was much less extensive than the limits imposed by this factor. A relationship with the thermocline was strongly suggested by night catches but was not evident for the few fish caught by day (Fig. 2).

Age determinations of chums caught in the adjustable net were as follows:

Age	3	4	Unknown
May 17 to June 10, no.	8	80	8
%	8	83	8
June 22 to July 5, no.	15	9	3
%	56	33	11

All chums caught in the earlier period were considered to be maturing fish. In the later period, 30% were placed in this category. Preliminary examination of the data has not disclosed differences in vertical distribution that can be associated with differences in age or state of maturation.

Pink salmon. The small number of pink salmon caught does not permit any detailed conclusions on depth distribution. The species was taken at depths between the surface and the 120-foot level.

General. The data show that on a comparative basis the majority of the sockeye and chum caught (by day and by night and throughout the fishing season) were at levels below the reach of standard floating gill-nets.

The 1960 observations were made in a restricted area. A general picture of vertical distribution cannot be presented until findings have been reported from other parts of the North Pacific Ocean and Bering Sea.

2. Salmon Tagging in the Eastern Gulf of Alaska

The purse seiner *Key West II* was chartered by Canada to tag salmon in the eastern part of the Gulf of Alaska during the summer of 1960. The charter

commenced on May 16 and terminated on August 13, a period of 90 days. The main effort was concentrated in the areas bounded by North Latitudes 56° and 54° out to 145° West Longitude (about 400 miles offshore), and along the west coast of the Queen Charlotte Islands. During the last cruise the vessel fished off

TABLE II. Seine sets and salmon catches, MV *Key West II*, 1960

Obs. No.	Date	Lat. N.	Long. W.	Sockeye.	Pink	Chum	Coho	Chinook	Total
KW-2	23/5	52°07′	131°31′	—	—	—	—	—	—
KW-3	23/5	52°07′	131°31′	2	30	—	—	—	32
KW-7	25/5	54°34′	133°43′	—	—	—	—	—	—
KW-13	30/5	56°00′	139°38′	3	—	—	—	—	3
KW-14	30/5	55°58′	139°36′	1	—	—	—	—	1
KW-22	2/6	54°08′	140°43′	—	—	—	—	—	—
KW-23	3/6	54°00′	138°05′	3	—	—	—	—	3
KW-24	3/6	54°05′	137°35′	1	—	—	—	—	1
KW-26	4/6	54°05′	135°00′	1	2	—	—	—	3
KW-28	7/6	54°17′	132°58′	—	1	3	—	2	6
KW-29	8/6	54°10′	133°22′	—	—	—	—	—	—
KW-30	8/6	54°00′	133°20′	—	—	8	—	—	8
KW-31	9/6	54°13′	133°13′	—	14	—	2	2	18
KW-32	16/6	54°47′	133°24′	—	3	—	1	—	4
KW-34	19/6	55°13′	134°42′	—	16	—	—	—	16
KW-36	26/6	55°51′	136°20′	—	33	—	1	1	35
KW-38	27/6	55°51′	136°23′	1	33	10	—	—	44
KW-39	27/6	55°51′	136°24′	—	3	—	—	—	3
KW-40	27/6	55°50′	136°55′	—	1	—	—	—	1
KW-45	8/7	53°39′	133°08′	—	2	—	—	—	2
KW-46	8/7	53°39′	133°08′	7	4	—	—	—	11
KW-47	9/7	53°36′	133°04′	—	—	17	—	—	17
KW-48	9/7	53°36′	133°04′	1	2	1	—	—	4
KW-49	9/7	53°36′	133°04′	—	—	23	—	6	29
KW-50	10/7	53°37′	133°20′	—	1	—	—	—	1
KW-51	10/7	53°37′	133°20′	—	3	—	—	—	3
KW-53	11/7	52°52′	132°17′	—	1	—	5	1	7
KW-54	15/7	54°11′	133°10′	1	—	—	—	—	1
KW-55	18/7	52°41′	132°02′	—	—	—	—	—	—
KW-56	19/7	52°04′	131°15′	—	—	3	—	—	3
KW-57	19/7	52°00′	130°56′	—	—	—	—	—	—
KW-58	20/7	51°48′	130°39′	3	4	—	—	—	7
KW-60	20/7	51°32′	130°02′	1	1	2	—	—	4
KW-62	21/7	51°02′	128°58′	3	6	1	—	—	10
KW-63	21/7	50°41′	128°29′	9	8	—	—	3	20
KW-64	27/7	48°35′	125°06′	36	1	—	21	2	60
KW-65	27/7	48°34′	124°52′	185	—	—	15	—	200
KW-66	28/7	48°31′	124°31′	297	1	—	—	1	299
KW-67	28/7	48°31′	124°31′	137	—	—	1	2	140
KW-68	29/7	48°29′	125°06′	1	—	—	3	—	4
KW-69	29/7	48°45′	125°26′	29	—	—	7	3	39
KW-70	30/7	48°54′	125°34′	7	—	—	10	23	40
KW-71	31/7	48°55′	126°02′	10	—	—	15	4	29
KW-72	1/8	49°14′	126°26′	69	—	—	2	—	71
KW-73	1/8	49°12′	126°39′	—	1	—	4	1	6
KW-74	2/8	49°30′	127°13′	—	—	—	—	—	—
KW-75	2/8	49°52′	127°16′	32	—	—	5	1	38
KW-77	4/8	50°01′	127°44′	7	4	—	11	8	30
KW-78	6/8	50°26′	129°09′	—	1	—	8	3	12
				847	176	68	111	63	1265*

* Also 1 steelhead, Obs. No. KW–45.

TABLE III (a). Recoveries from taggings off southeast Alaska and the Queen Charlotte Islands.

Tag No.	Species	Tagged			Recovered
MS 080	Pink	19/6	55°13′N	134°42′W	27/8—nr. Cape Addington, Alaska
MS 099	Pink	26/6	55°51′N	136°20′W	18/7—Namu, B. C.
MS 096	Pink	26/6	55°51′N	136°20′W	30/8—Kitkatla Inlet, B. C.
MS 166	Pink	27/6	55°51′N	136°23′W	11/7—Swann Is., Seymour Can., Alaska
MS 103	Pink	27/6	55°51′N	136°20′W	25/7—Gravina Is., Clarence Str., Alaska
MS 173	Pink	27/6	55°51′N	136°24′W	26/7—Funter Bay, Alaska
MS 272	Pink(?)	21/7	50°41′N	128°29′W	31/7—Bella Coola, B. C.
MS 055	Chum	8/6	54°00′N	133°20′W	10/7—Kincolith, Nass R., B. C.
MS 157	Chum	27/6	55°51′N	136°23′W	?/7—Quadra Arm, Clarence Str., Alaska
MS 193	Chum	9/7	53°36′N	133°04′W	8/8—Munsie Pt., Seaforth Channel, B. C.
MS 198	Chum	9/7	53°36′N	133°04′W	2/8—Fisher Channel, B. C.
MS 237	Chum	9/7	53°36′N	133°04′W	? —Garnet Pt., Alaska
MS 146	Sockeye	27/6	55°51′N	136°23′W	26/7—Stikine R., Alaska
MS 187	Sockeye	8/7	53°39′N	133°08′W	Week of July 20, Wright Sound, B. C.
MS 220	Chinook	9/7	53°36′N	133°04′W	31/1—Spike Rk. (Umatilla Rk.), Wash.
MS 247	Chinook	11/7	52°52′N	132°17′W	16/8—Barnston Is. slough, Fraser R., B. C.
MS 243	Coho	11/7	52°52′N	132°17′W	8/8—Kwakume Pt., Fitzhugh Sd., B. C.

TABLE III (b). Recoveries from taggings off the west coast of Vancouver Island.

Tag No.	Species	Tagged			Recovered
MS 779	Coho	28/7	48°31′N	124°31′W	2/8—San Juan, B. C.
MS 967	Coho	29/7	48°29′N	125°06′W	25/8—Sekiu, Wash. (?)
MS 1012	Coho	30/7	48°54′N	125°34′W	16/8—San Juan, B. C.
MS 1024	Coho	30/7	48°54′N	125°34′W	5/9—Pt. Gardner, Everett, Wash.
MS 1042	Coho	30/7	48°54′N	125°34′W	26/9—Strait of Juan de Fuca
MS 1052	Coho	31/7	48°55′N	126°02′W	18/9—Sequi, Wash.
MS 1054	Coho	31/7	48°55′N	126°02′W	? —Skagit Bay, Wash.
MS 1060	Coho	31/7	48°55′N	126°02′W	13/8—Cape Cook, B. C.
MS 1072	Coho	31/7	48°55′N	126°02′W	7/8—Sooke, B. C.
MS 1073	Coho	31/7	48°55′N	126°02′W	11/8—Estevan Pt., B. C.
MS 1204	Coho	4/8	50°01′N	127°44′W	28/9—Canoe Pass, Fraser R., B. C.
MS 1232	Coho	6/8	50°26′N	129°09′W	25/8—Estevan Pt., B. C.
MS 273	Chinook	21/7	50°41′N	128°29′W	11/9—Nehalem R., Oregon
MS 1046	Chinook	30/7	48°54′N	125°34′W	? —Kalama R., Wash.
MS 1155	Chinook	2/8	49°52′N	127°16′W	4/10—Frankfort, Columbia R., Wash.
MS 1197	Chinook	4/8	50°01′N	127°44′W	22/8—Alderbrook, Columbia R. fishery
MS 1231	Chinook	6/8	50°26′N	129°09′W	25/8—Steveston, B. C,
	Sockeye	Some 230 sockeye recoveries have been reported to date, mainly from Convention waters in British Columbia and Washington. Information from the International Pacific Salmon Fisheries Commission indicates that the speed of migration of these fish was consistent with the speeds of sockeye tagged in earlier years at Sooke, B. C.			

the west coast of Vancouver Island. The tags used were Petersen-type plastic discs.

With the exception of positions near the entrance to the Strait of Juan de Fuca, salmon were generally very scarce during the 1960 season. Also, bad weather and unfavourable seas seriously hampered the operations in the northern areas and resulted in very small catches. For the whole season, a total of 49 sets were made; 1,268 salmon were caught (including 3 by long-line) of which 1,226 were tagged. The great bulk of the catch (mainly sockeye) was made off the west coast of Vancouver Island at the end of the season. In the northern areas the largest single catch was only 44 fish, and the average per set only 8.5 fish.

Invariably larger catches were made close inshore; whenever the vessel fished offshore few or no salmon were taken. With one or two exceptions, "jumpers" were observed only off the west coast of Vancouver Island close inshore.

A Japanese-type horizontal long-line (employing a

total of 250 hooks) was tried out on several occasions. It caught 3 pink salmon and 3 black cod. It is believed that the general scarcity of salmon, their wide dispersal in both horizontal and vertical planes, and the type of bait used, were factors contributing to the small catch. Strips of frozen and salted herring, and coloured plastic lures (" hoochie-koochies ") were used; all 6 fish were taken by the lures.

Plankton hauls (standard INPFC net and a 3-ft. Isaacs-Kidd midwater trawl) and oceanographic observations (water temperatures and water samples) were made throughout the season.

The seining effort and catches are summarized in Table II and recoveries in Table III. The rate of recovery from all salmon tagged in the northern areas was 5.7%; that from the sockeye tagged off the west coast of Vancouver Island was 28.6%.

3. Ocean Distribution of Rivers and Smith Inlets Sockeye

Studies in co-operation with United States investigators have revealed that the scale patterns of sockeye salmon from Rivers and Smith Inlets are similar and differ from those of all other known stocks. So apparent are these differences that separation is possible in some cases on a visual basis. Characters considered typical of these two stocks include (1) a small fresh-water zone, (2) narrow-spaced circuli in the first ocean year, and (3) the width of the second ocean growth zone exceeds that of the first. Values for these characters for Rivers and Smith Inlets scales, as well as those for other stocks examined, are given in Table IV. These values in combination clearly indicate the differences between the Rivers and Smith Inlets types and sockeye from other areas. The apparent similarity between the scale patterns reported by Gilbert in 1914 and by current investigators suggests that the characteristics observed are consistent for these stocks rather than peculiar to certain brood years.

Table IV. Summary of scale characters of sockeye salmon of known origin.

Origin	Sample size	Freshwater zone				Radius of 1st annulus (mm) /No. circuli in 1st annulus		II ocean annulus / I ocean annulus	
		No. circuli		Radius (mm.) × 100					
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Fraser R.	20	10–18	14.0	30–55	38.8	3.0–4.3	3.75	0.5–1.3	0.82
Smith I.	21	6–16	9.6	16–48	23.7	2.6–3.9	3.12	0.9–1.9	1.40
Rivers I.	23	5–13	9.7	14–38	23.4	2.5–3.6	2.95	1.1–1.9	1.43
Skeena R.	20	13–15	13.9	37–59	42.8	3.4–4.4	3.82	0.5–0.9	0.74
Bristol Bay	20	9–19	12.8	28–52	37.3	3.5–4.9	4.10	0.5–1.1	0.71
Bolshaya R.	20	8–14	10.1	23–37	29.3	3.4–4.6	3.92	0.5–0.9	0.65

Examination of every tenth scale from scale samples collected from the commercial catch in 1958 in the Rivers Inlet area indicated that 126 of 156 sockeye, or 76.2%, possessed the typical pattern. The remainder may have included Rivers and Smith Inlets fish possessing atypical patterns, or other stocks passing through the area en route to their spawning grounds elsewhere.

Of more than 5,500 scales examined from sockeye caught on the high seas by Canadian, Japanese and United States research vessels in 1957, 1958 and 1959, 45 were considered to be of Rivers and Smith Inlets types. Values for the characters of these fish are summarized in Table V. Comparing this table with Table IV, the values for Rivers and Smith Inlets indicate a high degree of similarity, supporting the belief that the origins of these fish were either Rivers or Smith Inlets.

Table V. Summary of scale characters of presumed Rivers and Smith Inlets sockeye caught on the high seas.

Year	Number	Freshwater zone				Radius of 1st annulus (mm) / No. circuli in 1st annulus		II ocean annulus / I ocean annulus	
		No. circuli		Radius (mm.) × 100					
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1957	12	6–18	10.7	19–54	29.5	2.5–3.5	3.00	1.1–1.7	1.33
1958	18	7–14	9.8	19–32	26.3	2.7–4.3	3.28	1.0–2.0	1.23
1959	15	7–12	9.3	18–38	26.4	2.3–4.5	3.15	1.0–1.9	1.34

The high-seas locations of Rivers and Smith Inlets type sockeye are given in Figure 3. From these it is seen that from mid-May through to mid-August these

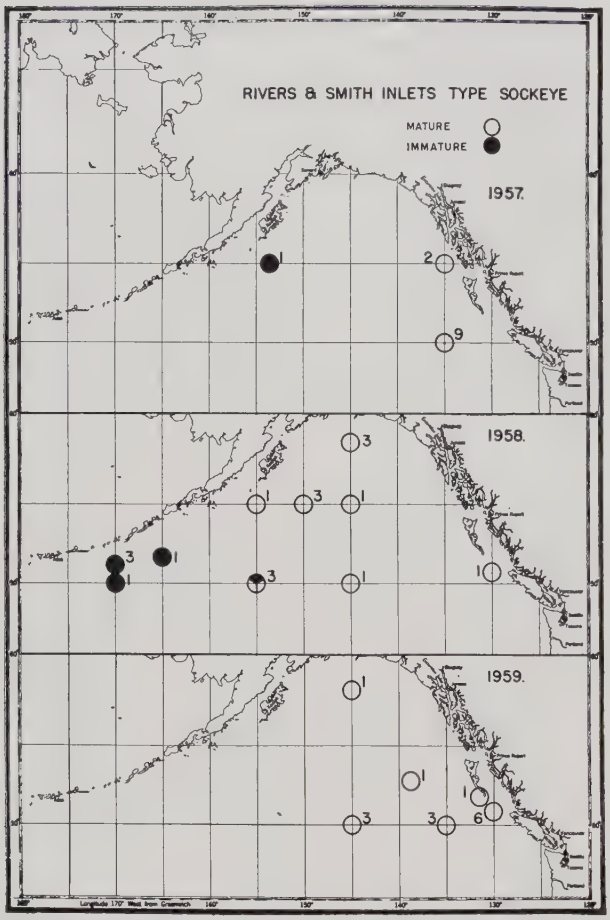


FIGURE 3. High-seas distribution of Rivers and Smith Inlets type sockeye.

stocks were distributed generally within the Gulf of Alaska as far west as Longitude 170° W. Information about distribution in 1959 is partial since it is based on Canadian research vessel catches only. Examination of scale samples of catches either by the Japanese high-seas commercial fishery or by research vessels in other regions of the North Pacific and the Bering Sea have failed, to this time, to indicate the occurrence of these sockeye elsewhere. That some individuals can occur further westward is shown, however, by a sockeye salmon tagged south of Kiska (51° 47′ N., 177° 45′ W.) as an immature in 1957 and recovered two years later in Rivers Inlet.

A consideration of the catches of immature and maturing individuals reveals that the two groups are distributed differently. Mature individuals were caught from off the British Columbia coast westward to Longitude 155° W., being present off the British Columbia coast as early as mid-June and persisting until early August. Along Longitude 155° W. they were present as late as late June. Immature individuals, in their second ocean year, were caught in waters between Longitudes 153° W. and 170° W. between late June and mid-August. Information on the oceanic distribution of one-ocean-year fish is lacking.

4. Study of Sockeye Salmon Parasites to Distinguish Stocks

The parasites of pink and sockeye salmon have been thoroughly studied from the point of view of determining their usefulness as " natural markers " of the geographical origin of these fish caught on the high seas. In the case of pink salmon, as reported in earlier annual reports, the results were not promising and the work on this species was discontinued. On the other hand, significant findings were achieved with sockeye salmon. Two of the more than 50 species of parasites encountered in sockeye proved to be useful indicators of the high-seas distribution of some stocks of sockeye. These are the freshwater parasites *Triaenophorus crassus* (Cestoda) and *Dacnitis truttae* (Nematoda). Details of the life history and ecology of these parasites have been presented in earlier reports. *Triaenophorus* is found in some western Alaskan sockeye and *Dacnitis* occurs in some sockeye of Asian origin. Since streams north of Bristol Bay in western Alaska produce negligible quantities of sockeye, relative to the production in Bristol Bay, the *Triaenophorus*-infected sockeye are mainly from Bristol Bay. *Triaenophorus* is by far the more important of the two indicator parasites because apparently it is more prevalent in western Alaskan sockeye than is *Dacnitis* in Asian sockeye.

The present summary presents the results obtaincd from samples collected in 1959 on the distribution of *Triaenophorus*-infected and *Dacnitis*-infected sockeye. Results of the examination of samples collected in the years 1955 to 1958 were summarized in the Annual Reports for 1955, 1956–57, 1957–58, 1958–59 and 1959–60.

Close to 5,000 sockeye, collected almost entirely from May to August, 1959, were examined. This represents an increase of 50% over the previous year's sampling and is a little more than 60% of the total number of sockeye sampled in the 4 years from 1955 to 1958, inclusive.

The bulk of the increase was in the high-seas samples, particularly of maturing fish. Area coverage for maturing fish was more extensive in the Bering Sea and for the first time some adequate samples of matur-

ing fish were obtained in May and June from immediately south of the Aleutians between 175° E. and about 169° W. Sampling of the spawning runs to North American streams was much the same as in 1958, the main exception being that the sample size was increased from 25 to 50 sockeye from each of the main Bristol Bay rivers. Also, samples from two Asian rivers (almost all from the Ozernaya River, west Kamchatka) were available for the first time since this study was initiated.

Lists of the samples of smolts, of adults from their rivers of origin, and of high-seas specimens are presented in Tables VI, VII and VIII, respectively. The numbers of sockeye and the date of collection of each sample are shown and for the high seas the numbers of maturing and immature sockeye (as determined by gonad development) in each sample are given. In these tables the incidence of *Triaenophorus* and *Dacnitis* in the maturing and immature fish from each location are included. The number of fish in each sample which had spent only one year at sea is shown; almost all of these were immatures. The total number of smolts examined was 299, the number of adults from coastal areas 761 (617 from North America and 144 from Asia) and the number of high-seas sockeye 3,900 (2,528 maturing, 1,353 immatures and 19 undetermined). Of the maturing sockeye from the high seas, 2,168 were taken in May and June and only 360 in July and August. Of the immatures, 375 were taken in May and June and 978 in July and August. It is thus apparent that most of the May-June samples consisted of maturing fish whereas in July and August the majority of the fish were immature.

The distribution of all adult samples from coastal areas and all high-seas samples can also be seen in Figure 4. In Figure 5 the distribution of samples of maturing fish are shown separately for the May-June and July-August periods. Figure 6 shows the distribution of the immatures for the same two periods.

High-seas Distribution of North American and Asiatic Sockeye in 1959 as Determined by Triaenophorus and Dacnitis.

In coastal adult and smolt samples, *Triaenophorus*-infected sockeye were again found only in western Alaska with the Wood River (Nushagak River system), Bristol Bay, showing the highest incidence as in previous years (Tables VI and VII and Figure 4).

Dacnitis truttae, as in previous years, was not found in any North American samples of smolts or adults returning to spawn. In an earlier report it was noted that *Dacnitis* has been reported in the USSR literature as occurring in sockeye in Kamchatka River and our finding it in the Okhotsk Sea samples from 1955 to 1958 suggested that it probably occurs in some sockeye originating on the west coast of Kamchatka. Corroborative evidence of its presence in west Kamchatka rivers was not obtained. *Dacnitis* was not found in 126 sockeye from the Ozernaya River nor in 5 sockeye from the Bolshaya River collected in 1959. However, in high-seas samples of maturing sockeye taken in the waters between southeast Kamchatka and the western Aleutians which, as will be noted later, seem to be almost entirely of Asian origin, only 2 out of 362 sockeye (338 in May-June and 24 in July-August) were infected with *Dacnitis*, i.e., about 0.06%. If a similar very low rate of infection prevailed in the Ozernaya and Bolshaya River stocks it is not surprising that *Dacnitis* was not found in the samples from these rivers. Furthermore, the Ozernaya River sample was taken at the end of the " run " (September 1) and the parasite fauna of these fish may not be representative of the main body of Ozernaya sockeye.

In Figure 4 and Table VIII the distribution of high-seas sockeye infected with *Triaenophorus* (i.e., of western Alaskan, mainly Bristol Bay, origin) or *Dacnitis* (i.e., of Asian origin) are shown in relation to all samples examined in 1959. One hundred and ninety-nine

TABLE VI. Incidence of *Triaenophorus* in sockeye smolt samples from North America in 1959.

Locality	Date collected	No. examined	Infected with *Triaenophorus*	
			No.	%
Port John, British Columbia	26-IV	25	—	—
Chignik River, Alaska	28-V	25	—	—
Bristol Bay, Alaska				
Ugashik River	29, 30-V	50	—	—
Egegik River	30-V	50	—	—
Naknek River	9-VII	49	4	8
Kvichak River	18-V	50	—	—
Wood River	18-VI	50	42	84
Total		299	46	

TABLE VII. Incidence of *Triaenophorus* in adult sockeye samples from coastal areas in 1959.

Reference letter	Locality	Date collected	No. examined	Infected with *Triaenophorus*	
				No.	%
	North America				
	Washington-Oregon				
A	Columbia River	24-VI	25	—	—
	British Columbia				
B	Fraser River	10-VIII	25	—	—
C	Rivers Inlet	11-VII	25	—	—
D	Skeena River	14-VIII	25	—	—
	Alaska				
E	Stikine River	22-VI	25	—	—
F	Copper River	5-VI	25	—	—
G	Kenai R., Cook Inlet	15-VII	26	—	—
H	Fish Creek, Cook Inlet	17, 18-VII	25	—	—
I	Karluk R., Kodiak Island	24-VI	25	—	—
J	Red R., Kodiak Island	25-VI	25	—	—
K	Chignik River	2-VIII	23	—	—
L	Bear River	23 to 31-VII	25	—	—
M	Ugashik R., Bristol Bay	14-VII	50	2	4
N	Egegik R., Bristol Bay	7-VII	50	—	—
O	Naknek R., Bristol Bay	2-VII	50	4	8
P	Kvichak R., Bristol Bay	14, 26-VII	49	2	4
Q	Wood R., Bristol Bay	29-VI	50	15	30
R	Togiak R., Bristol Bay	5-VII	45	—	—
S	Kuskokwim River	25-VI	24	2	8
	Asia (USSR)				
T	Ozernaya River	1-IX	139[a]	—	—
U	Bolshaya River	30-VIII	5	—	—
		Total North America	617	25	
		Total Asian	144		
		Total No. fish examined	761		

[a] The viscera of only 126 fish from the Ozernaya River were examined ; they were not available for the remaining 13 fish.

sockeye infected with *Triaenophorus* were found in high-seas samples from 145° W. in the Gulf of Alaska to as far west as 171° E. On the other hand, only 10 sockeye infected with *Dacnitis* have been observed in the 1959 samples; 9 came from about 171° E. and westward and one from about 51° N., 170° W.

Distribution of Maturing Sockeye.

Figure 5 and Table VIII show the distribution and incidence of *Triaenophorus*-infected and *Dacnitis*-infected sockeye in samples of maturing fish.

Only two *Dacnitis*-infected maturing sockeye were found in the 1959 samples. They were taken in late May and early June in the waters to the south and west of the extreme western Aleutians (at 48° N., 169° 12′ E. and at 51° 21′ N., 171° 20′ E.), an area in which a few sockeye have been identified as of Asian origin, because of their infection with *Dacnitis*, in each year since 1955.

The results of the distribution of *Triaenophorus*-infected maturing sockeye are far more significant. One hundred and fifty maturing sockeye infected with *Triaenophorus* were observed in the 1959 samples from 145° W. to 171° E. Those having spent 2 winters at sea were as widely distributed as those having spent 3 winters at sea (Table IX and Figure 7).

One hundred forty-seven of the *Triaenophorus*-infected maturing sockeye were found in samples taken in May and June; 2 were caught in early July and 1 in early August (Figure 5 and Table VIII). The scarcity of *Triaenophorus*-infected sockeye on the high seas in July and August is in accord with the timing of the " runs " arriving in Bristol Bay. Generally the peak of these spawning " runs " occurs within the first half of July. It appears that most of the maturing

TABLE VIII. Incidence of *Triaenophorus* and *Dacnitis* in high-seas sockeye samples collected in 1959.

Ref. No.	Locality	Date collected	No. examined					Infected with *Triaenophorus*				Infected with *Dacnitis*			
			Maturing	Immature	Undetermined	Total	1-ocean age[a]	Maturing		Immature		Maturing		Immature	
								No.	%	No.	%	No.	%	No.	%
1	51°N, 159°28′E	8-VIII	2	46	—	48	—	—	—	—	—	—	—	—	—
2	48°31′N, 162°31′E	15-VI	41	9	—	50	—	—	—	—	—	—	—	—	—
3	52°32′N, 163°48′E	5-VII	14	36	—	50	—	—	—	—	—	—	—	2	6
4	48°24′N, 163°55′E	15-VI	43	7	—	50	—	—	—	—	—	—	—	—	—
5	54°N, 164°E	19-VIII	—	4	—	4	—	—	—	—	—	—	—	—	—
6	54°N, 166°E	20-VIII	—	50	—	50[b]	—	—	—	—	—	—	—	—	—
7	46°21′N, 168°06′E	5-VI	30	20	—	50	—	—	—	—	—	—	—	—	—
8	48°48′N, 168°36′E	15-VII	8	42	—	50	—	—	—	—	—	—	—	2	5
9	48°N, 169°12′E	27-V	40	10	—	50	—	—	—	—	—	1	3	2	20
10	48°57′N, 169°29′E	26-V	39	11	—	50	—	—	—	—	—	—	—	1	9
11	57°N, 170°E	2-VIII	2	46	—	48	—	—	—	2	4	—	—	—	—
12	49°06′N, 170°52′E	25-VI	16	34	—	50	—	—	—	—	—	—	—	—	—
13	55°N, 171°E	8-VI	46	—	—	46	—	1	2	—	—	—	—	—	—
14	54°20′N, 171°E	6-VI	46	—	—	46	—	1	2	—	—	—	—	—	—
15	51°21′N, 171°20′E	5-VI	47	3	—	50	—	—	—	—	—	1	2	—	—
16	50°25′N, 171°20′E	28-V	20	—	—	20	—	—	—	—	—	—	—	—	—
17	48°20′N, 172°08′E	27-V	26	—	—	26	—	—	—	—	—	—	—	—	—
18	56°49′N, 173°22′E	5-VII	44	6	—	50	—	1	2	—	—	—	—	—	—
19	58°N, 175°E	5-VII	8	40	—	48	—	—	—	1	3	—	—	—	—
20	56°N, 175°E	21-VI	16	—	—	16	—	1	6	—	—	—	—	—	—
21	55°N, 175°E	15-VII	2	14	—	16	—	—	—	2	14	—	—	—	—
22	54°N, 175°E	16-VII	6	2	—	8	—	—	—	—	—	—	—	—	—
23	51°30′N, 175°E	22-VII	6	36	—	42	—	—	—	5	14	—	—	—	—
24	51°N, 175°E	22-V	24	1	—	25	—	3	13	—	—	—	—	—	—
25	50°30′N, 175°E	23-VII	8	27	—	35	—	—	—	1	4	—	—	—	—
26	49°N, 175°E	24-V	22	2	—	24	—	—	—	—	—	—	—	—	—
27	48°N, 175°E	25-V	14	11	—	25	—	—	—	—	—	—	—	—	—
28	51°30′N, 175°03′E	20-V	19	1	—	20	—	2	11	—	—	—	—	—	—
29	56°N, 179°E	19-VI	14	1	—	15	—	—	—	—	—	—	—	—	—
30	52°59′N, 179°55′E	23-VI	40	7	—	47	—	4	10	—	—	—	—	—	—
31	60°N, 180°	30-VI	11	9	—	20	—	—	—	1	11	—	—	—	—
32	57°N, 180°	27-VI	95	5	—	100	—	9	9	—	—	—	—	—	—
33	56°N, 180°	26-VI	48	1	—	49	—	7	14	—	—	—	—	—	—
34	55°N, 180°	25-VI	46	1	—	47	—	4	9	—	—	—	—	—	—
35	53°30′N, 180°	13-VI	49	—	—	49	—	4	8	—	—	—	—	—	—
36	51°N, 180°	2-VI	63	1	—	64	—	2	3	—	—	—	—	—	—
37	56°N, 179°W	18-VI	39	1	—	40	—	3	8	—	—	—	—	—	—
38	52°38′N, 178°47′W	22-VI	44	3	—	47	—	9	20	—	—	—	—	—	—
39	51°29′N, 176°38′W	29-VII	45	51	1	97	7	—	—	1	2	—	—	—	—
40	51°32′N, 176°34′W	14-VI	49	—	—	49	—	3	6	—	—	—	—	—	—
41	51°32′N, 176°31′W	12-VI	96	—	—	96	—	11	11	—	—	—	—	—	—
42	56°N, 176°W	24-VI	49	1	—	50	—	4	8	—	—	—	—	—	—
43	55°N, 176°W	23-VI	49	1	—	50	—	5	10	—	—	—	—	—	—
44	54°N, 176°W	22-VI	83	—	—	83	—	8	10	—	—	—	—	—	—
45	49°01′N, 175°04′W	6-VI	5	15	—	20	—	—	—	—	—	—	—	—	—
46	57°N, 175°W	25-VI	92	1	—	93	—	10	11	—	—	—	—	—	—
47	56°N, 175°W	15-VI	22	—	—	22	—	—	—	—	—	—	—	—	—
48	52°59′N, 175°W	21-VI	21	6	—	27	—	2	10	2	33	—	—	—	—
49	51°N, 175°W	5-VIII	4	96	—	100	—	1	25	9	9	—	—	—	—
50	50°N, 175°W	6-VIII	1	48	—	49	—	—	—	3	6	—	—	—	—
51	49°N, 175°W	7-VIII	—	25	—	25	19	—	—	1	4	—	—	—	—
52	51°41′N, 171°57′W	28-V	49	—	—	49	—	2	4	—	—	—	—	—	—

Continued. ....

TABLE VIII. (continued)

Ref. No.	Locality	Date collected	No. examined					Infected with *Triaenophorus*				Infected with *Dacnitis*			
			Maturing	Immature	Undetermined	Total	1-ocean age[a]	Maturing No.	Maturing %	Immature No.	Immature %	Maturing No.	Maturing %	Immature No.	Immature %
53	53°58′N, 170°01′W	2-VII	19	1	—	20	—	1	5	—	—	—	—	—	—
54	59°N, 170°W	27-VI	48	—	—	48	—	5	10	—	—	—	—	—	—
55	58°N, 170°W	28-VI	45	—	—	45	—	3	7	—	—	—	—	—	—
56	55°59′N, 170°W	30-VI	99	1	—	100	—	12	12	—	—	—	—	—	—
57	53°18′N, 170°W	3-VII	13	2	—	15	—	—	—	—	—	—	—	—	—
58	51°N, 169°56′W	5-VII	25	24	1	50	—	—	—	—	—	—	—	1	4
59	52°N, 169°53′W	4-VII	10	89	—	99	3	—	—	5	6	—	—	—	—
60	51°56′N, 169°39′W	27-V	49	—	—	49	—	6	12	—	—	—	—	—	—
61	53°30′N, 165°W	11-VII	28	72	1	101	10	—	—	—	—	—	—	—	—
62	52°N, 165°W	6-VII	4	21	—	25	—	—	—	1	5	—	—	—	—
63	52°58′N, 164°58′W	12-VII	14	36	—	50	—	—	—	4	11	—	—	—	—
64	49°55′N, 160°05′W	22-VII	3	37	2	42	3	—	—	—	—	—	—	—	—
65	53°N, 160°W	14, 24, 25-VI	27	37	2	66	19	1	4	1	3	—	—	—	—
66	50°N, 160°W	27-VI	9	53	1	63	44	—	—	5	9	—	—	—	—
67	51°57′N, 159°58′W	24-VII	14	86	—	100	19	—	—	—	—	—	—	—	—
68	53°55′N, 159°40′W	26-VII	11	16	—	27	16	—	—	1	6	—	—	—	—
69	55°N, 155°W	10, 12-VI	97	7	3	107	10	11	11	—	—	—	—	—	—
70	50°N, 155°W	29-VI	—	50	—	50	46	—	—	3	6	—	—	—	—
71	55°N, 153°W	27-IV	13	—	—	13	—	—	—	—	—	—	—	—	—
72	54°10′N, 150°30′W	25, 26-VII	11	25	1	37	19	—	—	—	—	—	—	—	—
73	55°39′N, 150°23′W	10, 11-VI	31	15	—	46	—	—	—	—	—	—	—	—	—
74	55°N, 150°W	25 to 28-V	39	—	—	39	—	4	10	—	—	—	—	—	—
75	58°N, 145°W	25, 26-V	96	1	2	99	—	8	8	—	—	—	—	—	—
76	55°N, 145°W	21 to 23-V	69	4	3	76	6	2	3	—	—	—	—	—	—
77	50°N, 145°W	18, 19-V	16	33	1	50	—	—	—	1	3	—	—	—	—
78	52°30′N, 142°W	15 to 21-VII	23	—	1	24	1	—	—	—	—	—	—	—	—
79	55°N, 141°W	17 to 21-V	77	12	—	89	5	—	—	—	—	—	—	—	—
80	53°30′N, 138°53′W	7-VIII	8	—	—	8	—	—	—	—	—	—	—	—	—
81	50°N, 135°W	5 to 11-VII	27	—	—	27	—	—	—	—	—	—	—	—	—
		Totals	2,528	1,353	19	3,900	227	150		49		2		8	

No. matures May-June	2,168[c]	No. matures July-August	360
No. immatures May-June	375	No. immatures July-August	978
No. undetermined May-June	12	No. undetermined July-August	7
Total May-June	2,555	Total July-August	1,345

a) These fish are immature, except for a very few from the Gulf of Alaska.
b) The viscera of only 35 fish from 54°N, 166°E were examined ; they were not available for the remaining 15 fish.
c) Includes 13 fish taken in April.

western Alaskan sockeye leave the open ocean by the end of June but some may remain until early August as evidenced by the occurrence of a maturing *Triaenophorus*-infected sockeye in the mid-Aleutian area (51° N., 175° W.) on August 5. Similar findings from the 1958 samples were reported last year.

Some general conclusions on the quantitative distribution of Bristol Bay maturing sockeye in the samples examined can be drawn from data on the incidence of *Triaenophorus* in the samples taken in May and June, 1959. Precise proportions of Bristol Bay sockeye in the individual samples cannot be determined, however, because the numbers of fish in the standard samples from the individual Bristol Bay rivers, as well as in the high-seas samples, were not large enough to permit placing narrow confidence limits on the estimates.

To use data on rates of *Triaenophorus* infection to determine the quantitative distribution of maturing sockeye of Bristol Bay origin in high-seas samples, it is necessary to assume that the stocks from individual Bristol Bay rivers are homogeneously mixed in offshore waters during the months of May and June prior to their arrival in Bristol Bay. This assumption does not seem unreasonable. There is no apparent reason why the stocks from the different Bristol Bay

TABLE IX. Ocean age of sockeye infected with *Triaenophorus* in 1959 samples.

Locality	Maturing			Immature			
	2 years at sea	3 years at sea	Undetermined	1 year at sea	2 years at sea	3 years at sea	Undetermined
Bristol Bay, Alaska							
Ugashik River	2	—	—	—	—	—	—
Naknek River	2	2	—	—	—	—	—
Kvichak River	1	1	—	—	—	—	—
Wood River	14	—	1[a]	—	—	—	—
North of Bristol Bay							
Kuskokwim River	—	2	—	—	—	—	—
50°N, 145°W	—	—	—	—	1	—	—
55°N, 145°W	2	—	—	—	—	—	—
58°N, 145°W	6	2	—	—	—	—	—
55°N, 150°W	4	—	—	—	—	—	—
50°N, 155°W	—	—	—	3	—	—	—
55°N, 155°W	9	2	—	—	—	—	—
53°55′N, 159°40′W	—	—	—	1	—	—	—
50°N, 160°W	—	—	—	4	1	—	—
53°N, 160°W	1	—	—	—	1	—	—
52°58′N, 164°58′W	—	—	—	—	4	—	—
52°N, 165°W	—	—	—	—	1	—	—
51°56′N, 169°39′W	3	3	—	—	—	—	—
52°N, 169°53′W	—	—	—	1	4	—	—
55°59′N, 170°W	8	—	4[a]	—	—	—	—
58°N, 170°W	3	—	—	—	—	—	—
59°N, 170°W	4	1	—	—	—	—	—
53°58′N, 170°01′W	—	1	—	—	—	—	—
51°41′N, 171°57′W	1	1	—	—	—	—	—
49°N, 175°W	—	—	—	1	—	—	—
50°N, 175°W	—	—	—	—	3	—	—
51°N, 175°W	1	—	—	—	7	1	1[a]
52°59′N, 175°W	—	2	—	—	2	—	—
57°N, 175°W	6	3	1[a]	—	—	—	—
54°N, 176°W	4	4	—	—	—	—	—
55°N, 176°W	3	1	1[a]	—	—	—	—
56°N, 176°W	1	3	—	—	—	—	—
51°32′N, 176°31′W	9	1	1[a]	—	—	—	—
51°32′N, 176°34′W	1	1	1[a]	—	—	—	—
51°29′N, 176°38′W	—	—	—	—	—	—	1[a]
52°38′N, 178°47′W	6	3	—	—	—	—	—
56°N, 179°W	2	1	—	—	—	—	—
51°N, 180°	1	1	—	—	—	—	—
53°30′N, 180°	4	—	—	—	—	—	—
55°N, 180°	2	2	—	—	—	—	—
56°N, 180°	5	1	1[a]	—	—	—	—
57°N, 180°	5	3	1[a]	—	—	—	—
60°N, 180°	—	—	—	—	1	—	—
52°59′N, 179°55′E	3	1	—	—	—	—	—
51°30′N, 175°03′E	1	1	—	—	—	—	—
50°30′N, 175°E	—	—	—	—	1	—	—
51°N, 175°E	1	2	—	—	—	—	—
51°30′N, 175°E	—	—	—	—	5	—	—
55°N, 175°E	—	—	—	—	2	—	—
56°N, 175°E	—	1	—	—	—	—	—
58°N, 175°E	—	—	—	—	1	—	—
56°49′N, 173°22′E	1	—	—	—	—	—	—
54°20′N, 171°E	—	1	—	—	—	—	—
55°N, 171°E	1	—	—	—	—	—	—
57°N, 170°E	—	—	—	—	1	—	1[a]
Totals	117	47	11	10	35	1	3

a On the basis of weight and length these fish had spent at least 2 years at sea.

TABLE X. Incidence of *Triaenophorus* in adult sockeye runs to Bristol Bay in 1959.

Locality	Size of "run" (catch+escapement)	Sample size	% infected with *Triaenophorus*	Estimated no. infected in total "run"
Nushagak				
Wood River	3,500,000	50	30	1,050,000
Igushik River	1,000,000	0	?	?
Kvichak-Naknek				
Kvichak River	975,000	49	4	39,000
Branch River	1,200,000	0		
Naknek River	3,200,000	50	8	256,000
Egegik River	1,735,000	50	0	0
Ugashik River	635,000	50	4	25,400
Bear River	535,000	25	0	0
Sandy River	125,000	0	?	?
Total	12,905,000			1,370,400
Total in sampled areas	10,580,000			

Estimated incidence of *Triaenophorus* based on sampled areas—*ca.* 13%.

If Igushik, Branch and Sandy Rivers, which were not sampled, were free of *Triaenophorus*, the estimated incidence for all areas combined is *ca.* 10%.

If Igushik rate of infection is similar to the Wood River, Branch River similar to Kvichak River and Sandy River similar to Bear River, the estimated incidence for all areas combined is *ca.* 13%.

rivers, which are geographically relatively close to one another, should occupy significantly different areas during their oceanic period of life, and the time of arrival of the stocks in the different Bristol Bay rivers is approximately the same. Also, as noted above, *Triaenophorus*-infected maturing sockeye which had spent 2 years at sea showed much the same distribution as those which had spent 3 years at sea, suggesting that there is no significant difference in distribution of Bristol Bay sockeye of different ocean ages, at least during their last two months at sea.

In spawners returning to Bristol Bay as a whole, in 1959, the incidence of *Triaenophorus* was estimated to be between 10% and 13% (Table X).

From Figure 5 it is seen that the percentage of *Triaenophorus*-infected sockeye in samples of maturing fish from the Bering Sea from 180° to 170° W. in the latter half of June generally was quite uniform. Of 16 samples, 14 showed an incidence of 7 to 14% with 12 of these falling in the range of 8 to 12%. One sample had 20% infected and in a sample of 22 fish at 56° N., 175° W., none were infected. The mean incidence (about 10%) in 869 sockeye from this area was similar to that estimated for the Bristol Bay stocks as a whole. This suggests that these samples consisted largely of a uniform mixture of sockeye of Bristol Bay origin. At 171° E. in the Bering Sea the incidence of *Triaenophorus* was only 2% (about 1/5 to 1/7 of the percentage estimated for the Bristol Bay stocks as a whole) in each of 2 samples of 46 fish taken in early June, indicative of a marked reduction in the percentage of Bristol Bay sockeye in the samples. The sockeye predominating in these samples and accounting for this marked reduction of the percentage of Bristol Bay fish were most likely of Asian origin. Between 180° and 171° E. in the Bering Sea only two samples were available; these consisted of 14 and 16 maturing sockeye from 56° N., 179° E. and 56° N., 175° E., respectively, during the third week of June. One (6%) *Triaenophorus*-infected sockeye was found in the sample from 175° E. No reasonable quantitative interpretation can be drawn from the results from these small samples.

Samples taken in late May and early June from the area immediately south of the Aleutians (within about 60 miles or less) between approximately 169° W. and 175° E. showed less consistency between samples in the incidence of *Triaenophorus* than did those from the eastern half of the Bering Sea. Also, the overall incidence (8%) in 349 fish was lower than in the eastern half of the Bering Sea, but nevertheless relatively high. The incidence of *Triaenophorus* was as high at 175° E. as at 169° W. but varying percentages were observed between these two meridians. The results suggest that immediately south of the Aleutians between 169° W. and 175° E. the combined samples contained a

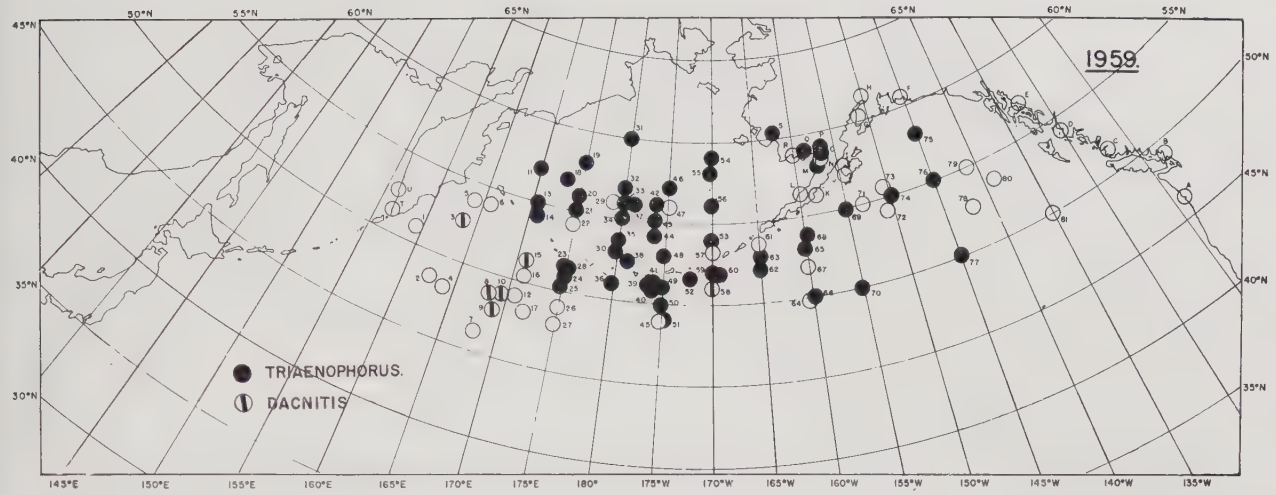


FIGURE 4. Distribution of high-seas and coastal sockeye samples in 1959 and occurrence of *Triaenophorus* and *Dacnitis*. Letters and numbers are locality references as given in Tables VII and VIII.

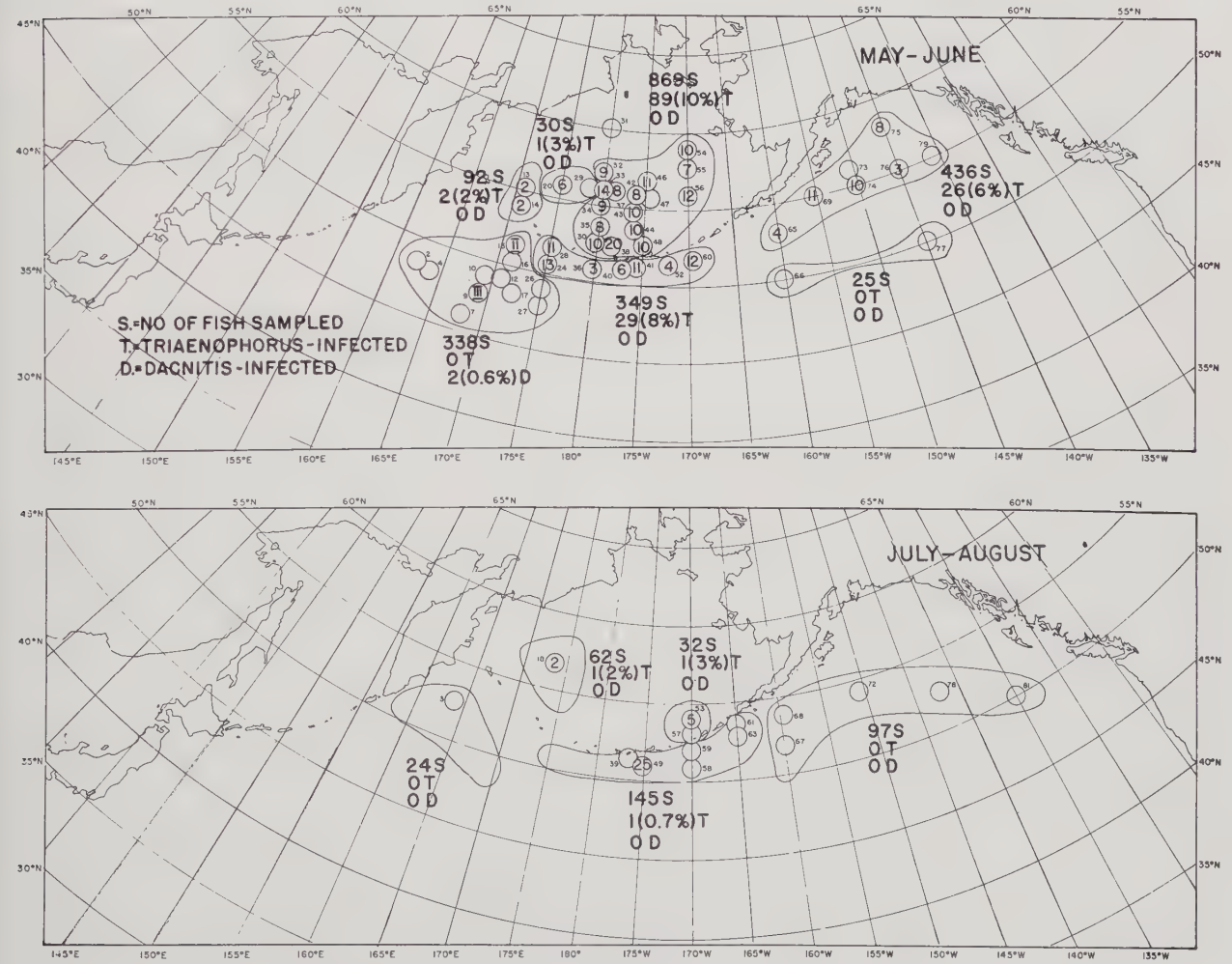


FIGURE 5. Percentage of *Triaenophorus*-infected and *Dacnitis*-infected sockeye in high-seas samples of *maturing* fish in 1959. Samples of less than 9 fish are not shown individually, except for a sample of 4 fish at station 49 in August. Arabic numerals and Roman numerals within the circles are per cent infection with *Triaenophorus* and *Dacnitis*, respectively. Small numerals outside the circles are locality references as in Table VIII.

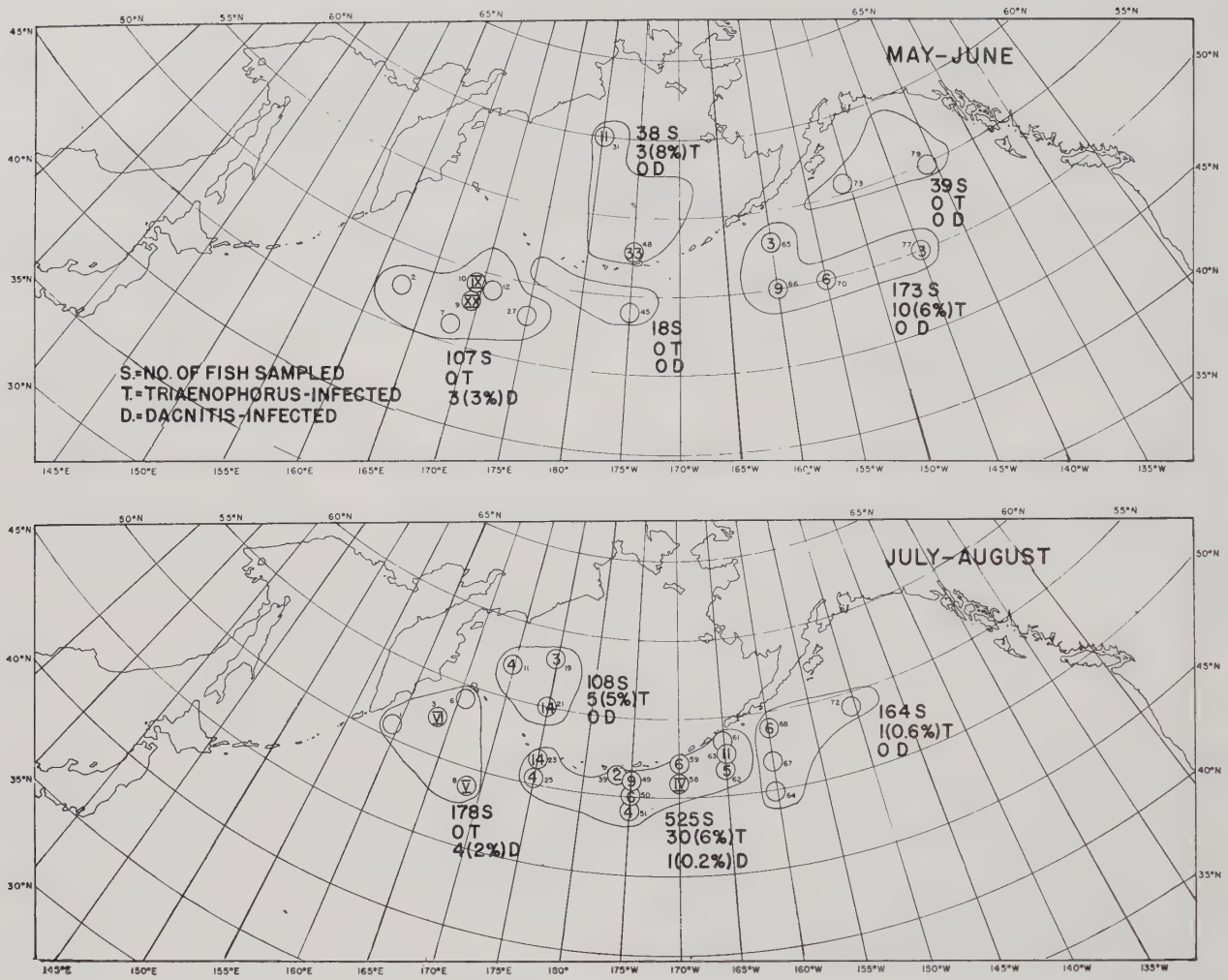


FIGURE 6. Percentage of *Triaenophorus*-infected and *Dacnitis*-infected sockeye in high-seas samples of *immature* fish in 1959. Samples of less than 9 fish are not included except for a sample of 6 fish at station 48 in June. Arabic and Roman numerals have the same significance as in Figure 5.

somewhat smaller (but still predominant) proportion of Bristol Bay sockeye than did those in the eastern half of the Bering Sea. The area of origin of the maturing sockeye present in the area in addition to those from Bristol Bay cannot be determined from our data but it is conceivable that they could be from either other North American areas or from Asia. Unfortunately, samples from close to the south side of the Aleutians west of 175° E. were not examined in 1959.

To the south and west of the extreme western Aleutians (i.e., from 175° E. and westward), excluding the waters within about 60 miles of the Aleutians, *Triaenophorus* was not found in any of 338 maturing sockeye collected in May and June, suggesting that there was a very small percentage, if any, of Bristol Bay fish in these samples (Fig. 5). It seems most likely that the maturing sockeye taken in the waters to the south and west of the extreme western Aleutians are mainly of Asian origin. The finding of *Dacnitis*-infected maturing sockeye within this region is positive evidence of the presence of Asian sockeye.

Triaenophorus-infected maturing sockeye were also well represented in the northern part of the Gulf of Alaska in late May and early June, much the same as in 1958. At 55° N., 155° W. on June 10 and 12 and at 55° N., 150° W. from May 25 to 28, the incidence of *Triaenophorus* in samples of 97 and 39 maturing sockeye was 11% and 10%, respectively, which is very similar to the incidence in Bristol Bay, suggesting that the samples consisted largely of Bristol Bay sockeye. At 58°N., 145°W. on May 25 and 26 a sample of 99 maturing fish yielded 8% infected with *Triaenophorus*, again indicating a high proportion of Bristol

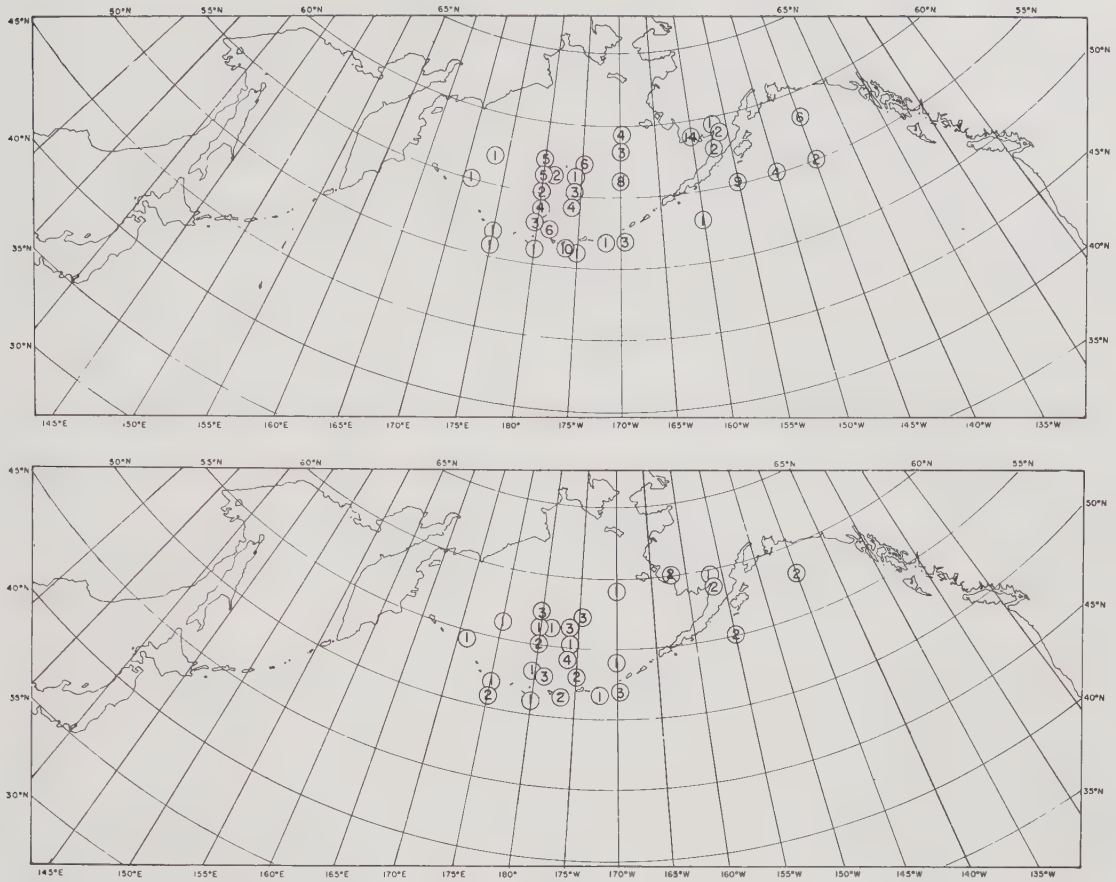


FIGURE 7. Distribution and number of *Triaenophorus*-infected *maturing* sockeye which have spent 2 and 3 winters at sea. Upper chart=2 winters. Lower chart=3 winters.

Bay sockeye. Proceeding eastward at 55° N. in May, there was a decrease in the incidence of *Triaenophorus*-infected sockeye down to zero at 141° W. The dilution of maturing Bristol Bay sockeye in May in the eastern half of the northern Gulf of Alaska is probably brought about by the presence of sockeye from North American areas to the south and east of the Alaska Peninsula.

At about 55° N., 150° W., two samples taken about two weeks apart appear to indicate that maturing Bristol Bay sockeye move out of the Gulf of Alaska quite rapidly. In the sample of 39 fish taken from May 25 to 28, 4 (10%) were infected with *Triaenophorus*, whereas a sample of 31 maturing sockeye taken on June 10 and 11 was entirely free of *Triaenophorus*. Further evidence that the sockeye present in the area in June were a different group from those found in May is offered by the fact that all sockeye caught in May were maturing whereas of those taken in June only about two-thirds were maturing.

Distribution of Immature Sockeye.

The high-seas distribution and percentages of immature sockeye infected with *Dacnitis* or *Triaenophorus* are shown in Figure 6 and Table VIII.

Eight *Dacnitis*-infected immature sockeye were found in the 1959 samples. All had spent either 2 or 3 winters at sea. Seven were taken off southeast Kamchatka between about 164° E. and 170° E. in late May and the first half of July, and one was caught at about 51° N., 170° W. in July. This latter record extends the eastward distribution of immature Asian sockeye previously determined by the presence of *Dacnitis*. In 1956 one was found at 175° W. in the Bering Sea and in 1958 another one was taken at 175° W. south of the Aleutians.

Forty-nine immature sockeye infected with *Triaenophorus* were found in the 1959 samples of immature fish—36 in July and August and 13 in May and June. They had spent one or two (rarely three) winters at sea (Fig. 8 and Table IX) and were found from 145°W. in the Gulf of Alaska to as far west as 175°E. south of the Aleutians and from 175° W. to 170° E.

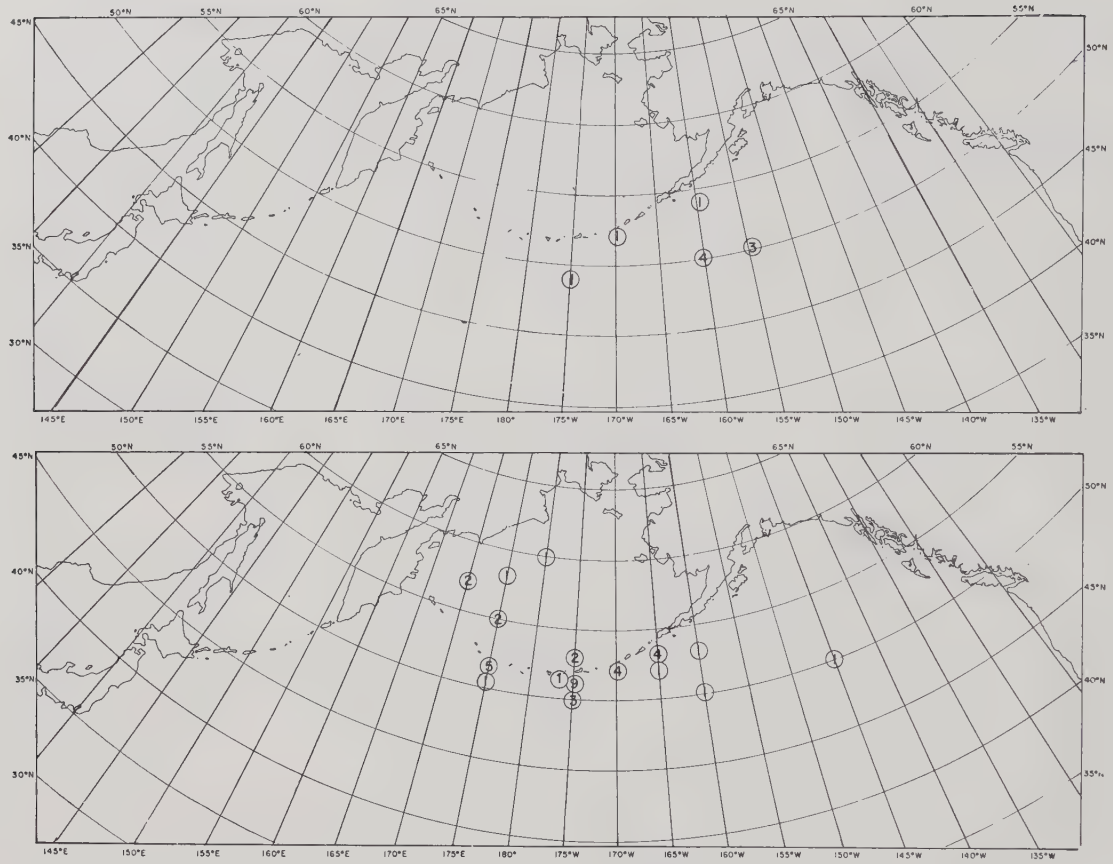


FIGURE 8. Distribution and number of *Triaenophorus*-infected *immature* sockeye according to numbers of winters spent at sea. Upper chart=1 winter. Lower chart=2 and 3 winters.

in the Bering Sea.

During July and August, *Triaenophorus*-infected immature sockeye were taken south of the Aleutians from 175° E. to 165° W. and at 160° W. in the western Gulf of Alaska and also in the Bering Sea at 170° E. and 175° E. In May and June, the immature *Triaenophorus*-infected sockeye were taken principally in the southern part of the Gulf of Alaska along 50° N., as far east as 145° W.; three were also present in small samples taken during the latter part of June in the Bering Sea at 60° N., 180°, and about 53° N., 175° W. The southern distribution of immatures in the Gulf of Alaska is in contrast to the more northern distribution of the maturing *Triaenophorus*-infected sockeye caught there.

The distribution of 1-ocean-winter and 2-ocean-winter immature sockeye infected with *Triaenophorus* is shown in Table IX and Figure 8. As noted in Table VIII, few 1-ocean-winter fish were examined from areas west of the Gulf of Alaska, although large catches of these young fish were made by research vessels in the Aleutian area (INPFC Annual Report for 1959). Therefore, it is impossible to make an adequate comparison of the ocean distribution of immature Bristol Bay sockeye of 1-ocean-winter age with that of older fish. In 1958, when samples of both 1-ocean- and 2-ocean-winter fish were examined from the waters to the north and south of the Aleutians, it was noted that *Triaenophorus* was found in both of these age-groups as far west as 175° E.

The application of rates of *Triaenophorus* infection of immature sockeye to quantitative analysis is far more complicated than for maturing fish, if at all possible, and has not been attempted.

5. Study of Chum Salmon Scales to Distinguish Stocks

Studies of scale characteristics of chum salmon taken from spawning grounds and coastal areas throughout the North Pacific area and on the high seas were continued. Previous reports have reviewed the results of the scale collections made in 1956 in both coastal and high-seas areas and in 1957 for those made in coastal areas. Scales collected in 1957 from

3,070 chums from the high seas and from 681 5-year-olds collected in coastal areas in 1958 have now been examined. From differences in first- and second-year circulus counts and annulus measurements of scales from over 60 areas of North America and 16 areas of Asia, an attempt was made to identify the area of origin of fish taken on the high seas in both 1956 and 1957. Because scale characteristics tend to vary between fish maturing at different ages, the present study was restricted to consideration of 4- and 5-year-old chums arising from the brood years of 1952 and 1953 only.

In Figures 9 and 10 limits for counts and measurements for shore samples for 4-year-olds from the various shore samples taken in 1956 and 1957 are shown. From examination of the distributions of characters, it can be seen that certain groups of fish have relatively unique characteristics and can be segregated from others. For example, first half of first year (C_a) values for Siberian chums (both brood years) have limits from 8 to 15. Almost no chums from any other areas have counts of less than 10. Thus, high-seas samples having significant quantities of fish with less than 10 circuli almost certainly would contain substantial numbers of Siberian chums. Similarly, only chums from British Columbia have last half of first year (C_b) values exceeding 22. Thus high-seas samples containing significant numbers of fish with C_b values exceeding 22 would almost certainly contain substantial numbers of fish originating in British Columbia.

By a simultaneous examination of pairs of characters in conjunction with an examination of single characters, some improvement in the degree of separation can be obtained. A method was devised which involved the establishment of a key in which 8 scale characters for fish taken on the high seas are compared with the same characters for fish of known origins sampled in

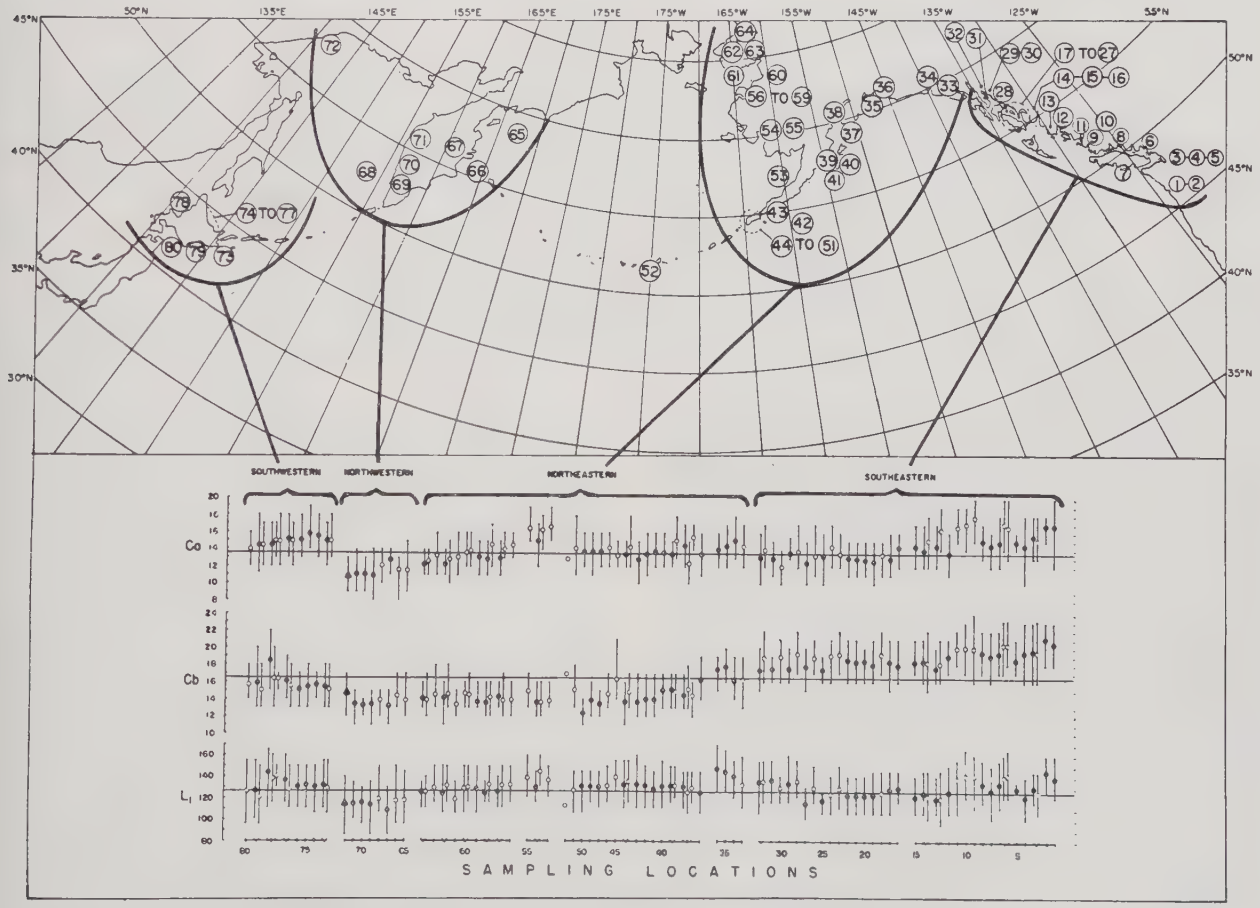


FIGURE 9. Mean values and arbitrary ranges of circulus counts for the first half of the first year (C_a), circulus counts for the last half of the first year (C_b) and first-year annulus widths (L_1) for 4-year old chum salmon collected in various coastal sampling areas. Open circles indicate values for samples collected in 1956, closed circles for samples collected in 1957 and triangles for a sample of 5-year-olds collected in the Kukhtui River in 1958.

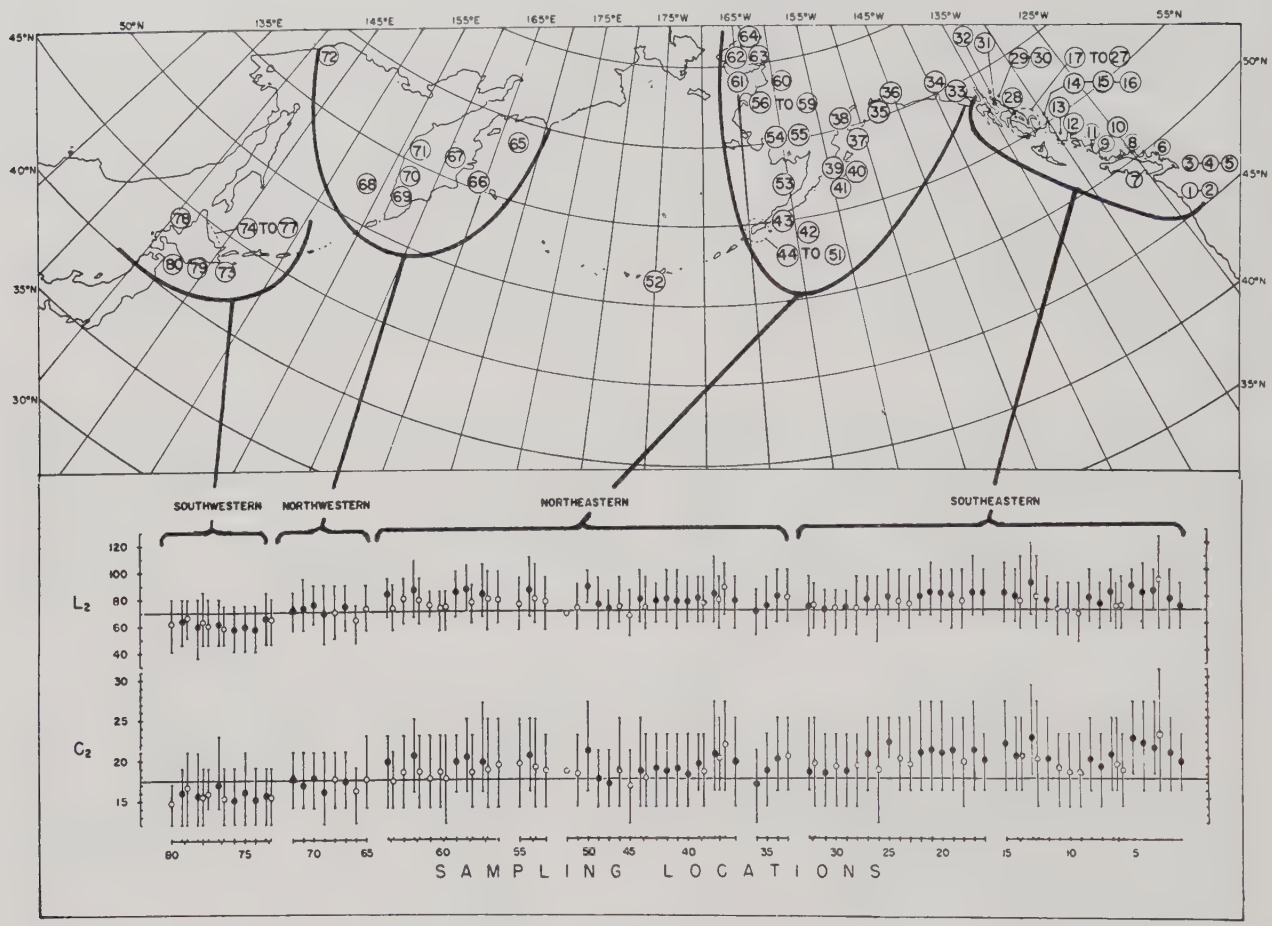


FIGURE 10. Mean values and arbitrary ranges of second-year annulus widths (L_2) and second-year circulus counts (C_2) for 4-year-old chum salmon collected in various coastal sampling areas. Open circles indicate values for samples collected in 1956, closed circles for samples collected in 1957 and triangles for a sample of 5-year-olds collected in the Kukhtui River in 1958.

coastal fishing areas or on spawning grounds. From these comparisons each fish taken on the high seas was classified according to the similarity of its scale pattern to scale patterns of fish originating in streams within 4 broad geographical areas: the Southeastern Region (from Oregon to central Alaska), the Northeastern Region (central, western and far northern Alaska), the Northwestern Region (here type samples were obtained almost exclusively from the Kamchatka Peninsula although it is believed that fish from most Asian producing areas along the northern Okhotsk Sea and on the Bering Sea coast of the USSR would exhibit similar scale patterns) and the Southwestern Region (type samples were obtained from Hokkaido only, but it is possible that chums from the more southerly USSR producing areas may exhibit similar characteristics). In many cases, fish taken on the high seas could be assigned precisely to one of the 4 regions. In other cases it was possible only to designate that the fish originated in either of 2 or in one of 3 or even all 4 of the regions.

As a test of the method, sub-samples of fish of known origin were processed in the same way as if they had occurred among samples taken on the high seas. These tests indicated that the precise region of origin of about half the fish originating in the Southeastern Region would be recognized correctly by this method. For an additional 15%, the precise region could not be determined, but the fish would be designated as originating in either the Southeastern or Northeastern Region and could therefore be assigned as North American fish. In all but 1% of the remaining cases neither the region nor the continent of origin could be determined. In about 1% of the cases either the region or continent of origin was misclassified. Somewhat smaller percentages of fish originating in the Northeastern (northern Alaska) and Northwestern (northern Asia) Regions could be classified as to region or continent of origin (33% and 31% respectively).

The number of cases in which wrong classification occurred was small (about 1% and 3% for the Northeastern and Northwestern Regions respectively). Because their scale characteristics are intermediate between those of Northwestern and North American chums, very few (around 6%) of the fish from the samples from Hokkaido (Southwestern Region) could be classified even to continent of origin. In 4.5% of the cases, the continent of origin was misclassified. Thus the methods used would be expected to provide relatively accurate identification of the region of origin of a significant proportion of those 4- and 5-year-old chums taken on the high seas which had originated in the streams of northern Asia and along the entire North American coastline. Very few of the fish originating in southern Asian chum streams would be identified.

In applying these methods to samples taken on the high seas (Fig. 11) a number of difficulties arose, stemming from the errors in classification described

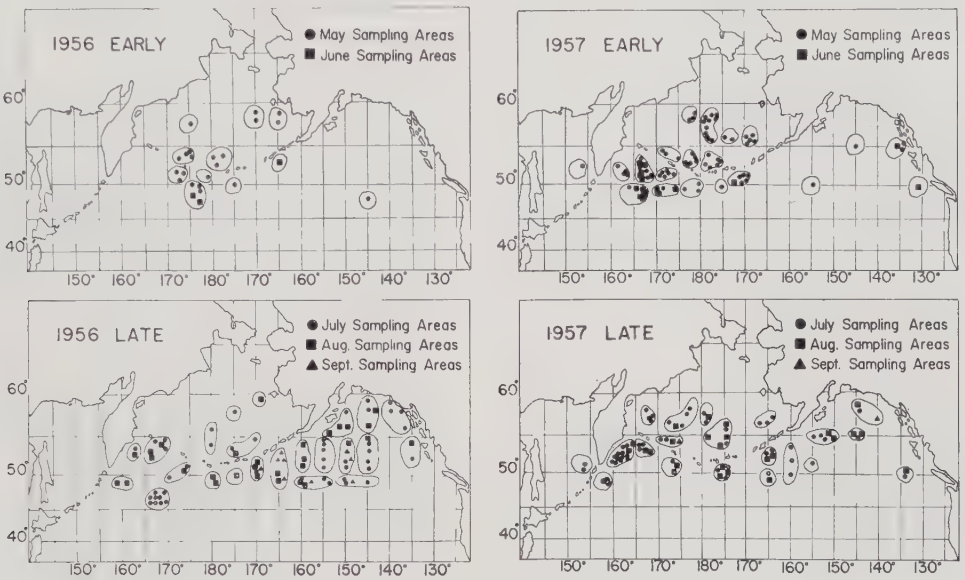


FIGURE 11. High-seas sampling areas in which chum salmon used for scale analyses were collected in 1956 and 1957.

above and possibly from the inadequacy of sampling in certain coastal areas (especially in Asia). While these difficulties prevented determination of the exact limits of distribution of the different stocks on the high seas, the study has provided a very reasonable picture of the centers of concentration of the populations originating in all regions except the Southwestern.

As a summary, Figures 12 and 13 have been prepared from the combined data for 1956 and 1957 to show the general distribution of fish from each of the 3 regions under consideration, during the early part of the sampling season (May and June) and during the late season (July to September). The results from the 1956 and 1957 collections were quite similar. For each of the stocks, the high-seas areas in which they predominated, the areas in which they were present in lesser proportions, and the areas in which they may have been present in small proportions but where possible errors in classification make final determinations difficult, are shown.

During the early part of both years (May and June, Fig. 12), most of the fish in the samples were probably matures, some of which would already be on their way to the spawning grounds. Except for the area immediately adjacent to the British Columbia-southeastern Alaska coast (where Southeastern fish predominated), sampling was restricted to the areas westward from 165° W. Fish from northern Alaska predominated in the eastern Bering Sea and south of the Aleutians around 165° W. Northern Asian fish apparently predominated throughout most of the rest of the western ocean, except along the southern fringe of the sampling area, especially eastward from 180°. Here the proportions of fish which could not be identified were very high, suggesting the presence of stocks (either Asian or North American) with intermediate scale characters. The area over which substantial intermingling occurred lay between 175° E. and at least as far eastward as 165° W. This zone of intermingling appeared to be widest near the Aleutians

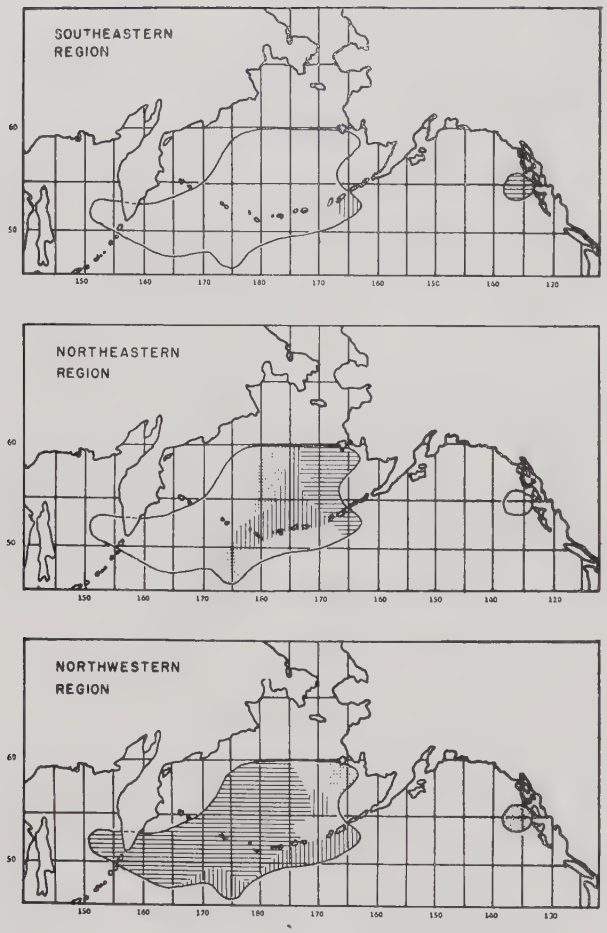


FIGURE 12. Apparent distribution of 4- and 5-year-old chums originating in the Southeastern (British Columbia-southeastern Alaska), Northeastern (northern Alaska), and Northwestern (northern U.S.S.R.) Regions on the high seas during May and June of 1956 and 1957. Black line encloses area sampled during 1956 and 1957. Horizontal bars indicate areas where fish from the designated region probably predominate. Vertical bars indicate where fish are probably present in smaller proportions and dotted areas indicate where fish may be present, but where errors in method prevent final conclusions. Clear areas indicate where fish from the designated regions are essentially absent.

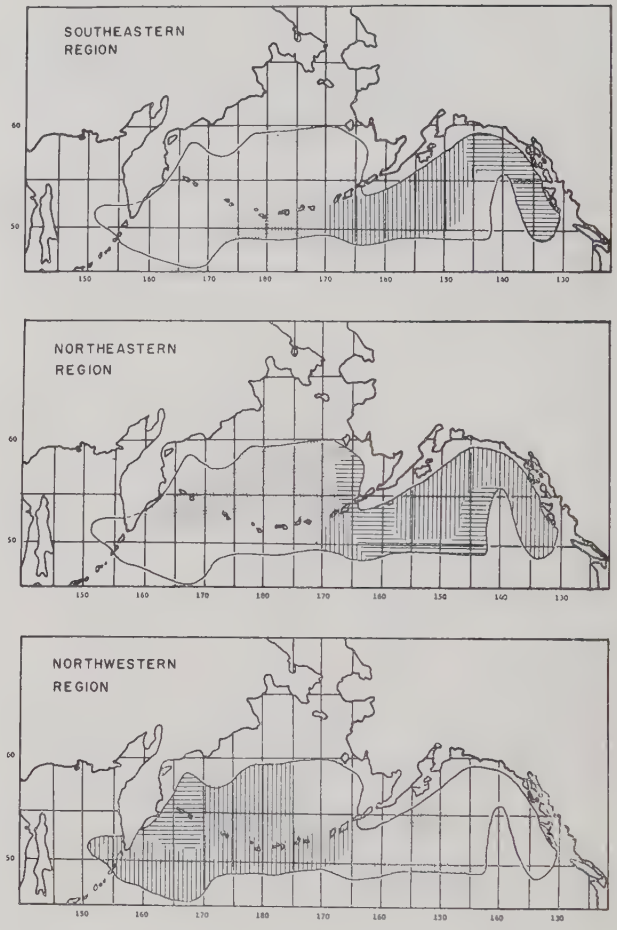


FIGURE 13. Apparent distribution of 4- and 5-year-old chums originating in the Southeastern (British Columbia-southeastern Alaska), Northeastern (northern Alaska), and Northwestern (northern U.S.S.R.) Regions on the high seas from July to September of 1956 and 1957. Black line encloses area sampled during 1956 and 1957. Horizontal bars indicate areas where fish from the designated region probably predominate. Vertical bars indicate where fish are probably present in smaller proportions and dotted areas indicate where fish may be present, but where errors in method prevent final conclusions. Clear areas indicate where fish from the designated regions are essentially absent.

and to be narrower further northward in the Bering Sea. The approximate boundary separating areas where Alaskan and northern USSR fish predominated appeared to be between 170° W. and 175° W. north of the Aleutians. Below the Aleutians, the presence of large proportions of unidentifiable fish makes establishment of a division line difficult. From the above considerations, in Figure 14, the approximate ranges of 4- and 5-year-old chums from North America and Asia are indicated.

Late in the season (July to September—See Fig. 13) sampling was more widespread and included a good coverage of the Gulf of Alaska as well as of the western part of the study area. As the season progressed it would be expected that mature chums destined to spawn during the summer months would rapidly emigrate from the high seas, leaving behind immature fish and populations of later spawning fish. The stocks of northern Asia are summer spawners and their distribution pattern as indicated by the scale studies, reflects their movement away from the central Bering Sea (where they clearly predominated early in the season—see Fig. 12) toward the Asian coast. The proportions of identifiable Northwestern chums were

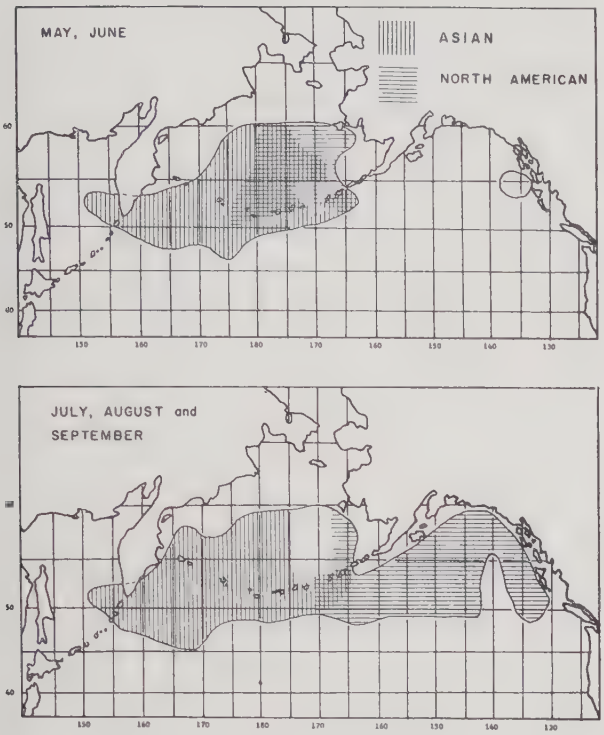


FIGURE 14. Apparent distribution of North American and Asian 4- and 5-year-old chums in various high-seas areas in 1956 and 1957. Cross-hatching indicates areas of intermingling.

very high along the Kamchatka coast (about the same as in the early season) and considerably lower than they had been in the spring everywhere else (except for one sampling area in the Gulf of Alaska—see below). Samples throughout most of the western North Pacific and Bering Sea contained moderate proportions of Northwestern fish and large proportions of unidentifiable fish, suggesting that the residual populations there could be made up of a high proportion of late spawning southern Asian fish (which are impossible to identify because of their intermediate scale characters).

In the late part of the season in the Bering Sea, fish originating in northern Alaska (the Northeastern Region) occupied essentially the same area as they did in the early part of the season. They also formed a major part of the population in the western Gulf of Alaska. Mature fish of Southeastern origin were concentrated against the eastern shore of the Gulf, but also occurred in smaller proportions along the northern rim of the Gulf westward to about 170° W. Samples of immature fish taken immediately south of Kodiak Island in July contained a high proportion of fish with typically northern Asian scales, suggesting the possible presence of some Asian fish in this area.

It is very difficult to establish the probable area over which intermingling between North American and Asian 4- and 5-year-old fish occurred late in the summer because the actual number of fish sampled in the central North Pacific and Bering Sea areas was too small, and because of the large numbers of unidentifiable fish present in samples from this area. At this time, it is not feasible to discuss in detail the relative abundance of fish in the different high-seas sampling areas as shown by high-seas fishing. However, one general comment may be helpful. Late season catches of older chums in the mid-ocean area, as shown, for example, by the 1956 data, are usually quite poor. Catches on either side of this area remain high at least until late August. These observations suggest a division between Asian and North American mature stocks as both move toward their spawning grounds. In 1956 this division area seemed to lie between 170° W. and 180°. From these considerations and study of data presented in Figure 13, in the late summer the extent of intermingling of Asian and North American 4- and 5-year-old chums (many of which are matures) is much less than that occurring in the early season. The approximate division line between areas in which one or the other predominated in 1956 and 1957 would appear to be in the general vicinity of 170° W. both north and south of the Aleutians (see Fig. 14).

The study of 4- and 5-year-olds provides only a limited picture of the distribution of chums on the high seas. Especially late in the season, immature 3-year-old and younger fish form large proportions of research vessel catches. Extension of the present study to include examination of these younger fish is necessary to provide a balanced description of the distribution of stocks originating from the two continents. In addition, chum scales collected since 1957 should be examined and the results compared with those derived from the 1956 and 1957 data.

6. Oceanography

A. Surveys of the Northeastern Pacific

Winter and summer surveys of the physical oceanography of the northeastern Pacific were again carried out in 1960. Observations at Ocean Weather Station "P" (Latitude 50° N., Longitude 145° W.) were continued, with sections at six-week intervals between that point and the coast.

January-February, 1960. The fourth consecutive mid-winter survey was carried out during the period January 11 to February 10, 1960, aboard H.M.C.S. *Beacon Hill* (Navy frigate).

The observed temperature distribution at 10 metres depth (Fig. 15—dots represent station positions) was similar to that observed during the previous winter. The comparison is represented in Figure 16 which illustrates the differences in temperatures between the mid-winter periods, 1959 and 1960 (hatched areas indicate colder water in 1960 than in 1959). Over most of the region the temperature anomalies were generally less than 0.4°C., except in the Gulf of Alaska where temperatures were colder in 1960 than in 1959. Temperatures were also slightly colder (less than 0.4°C.) along the British Columbia coast and in the mid-ocean region.

The intrusion of relatively warm water (Fig. 15) at 40° N. Latitude between 130° and 140° W. Longitude was again present, but slightly broader than previously. This intrusion appears to be a winter feature.

The salinity distribution at 10 metres depth (Fig. 17) confirms the features in the temperature distribution. There was an intrusion of relatively warm low salinity water westward along Latitude 55° N. Northward of this, relatively cold saline water, general-

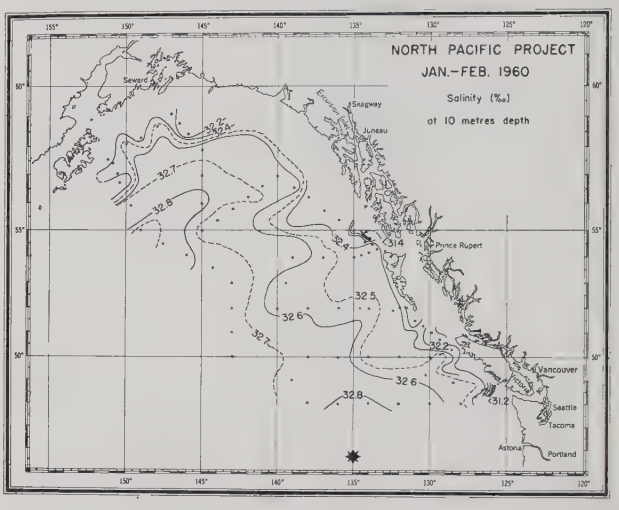


FIGURE 17.

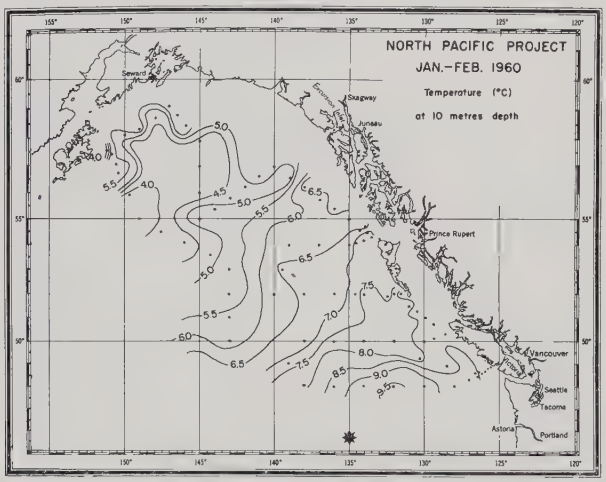


FIGURE 15.

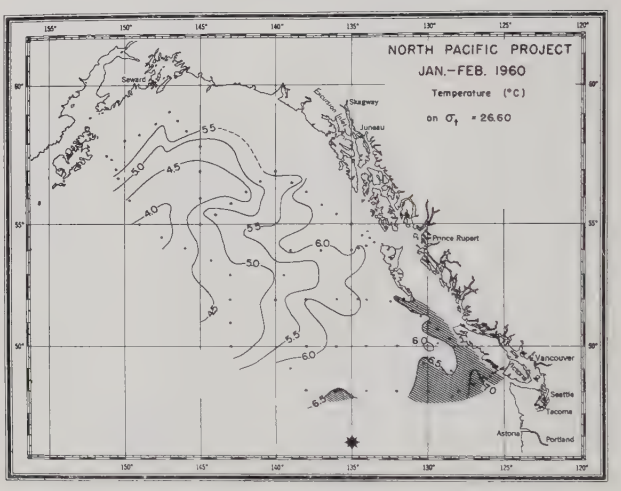


FIGURE 18.

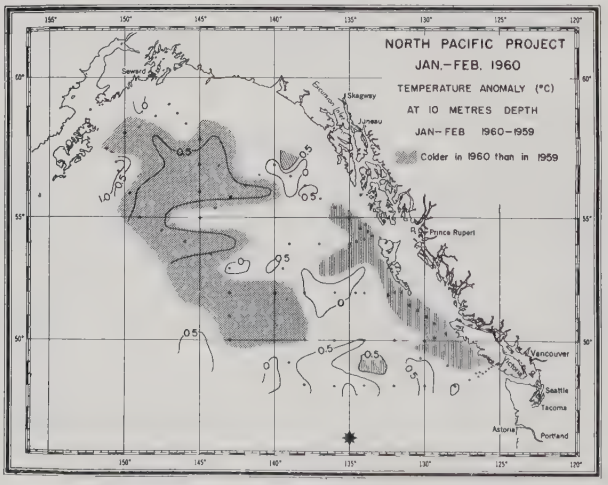


FIGURE 16.

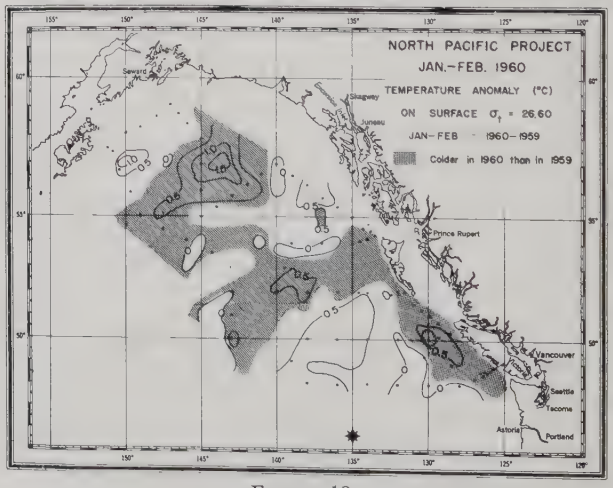
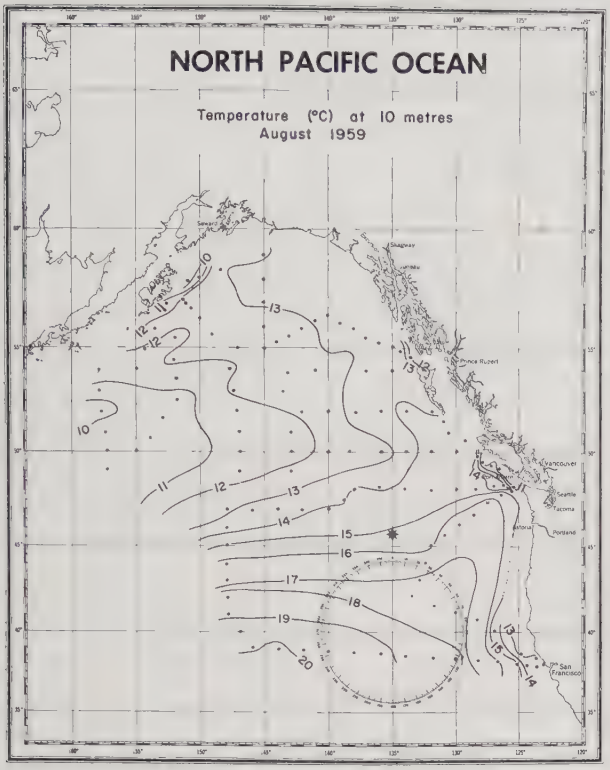


FIGURE 19.



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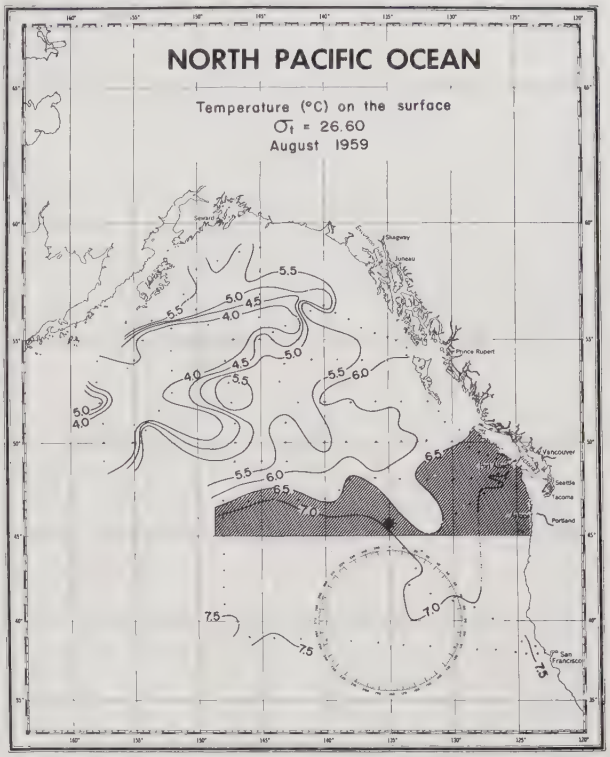


FIGURE 22.

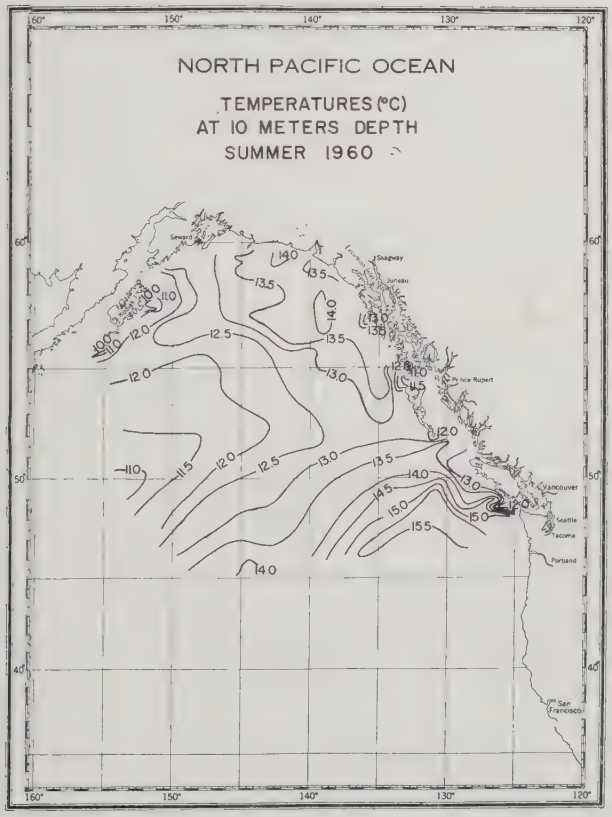
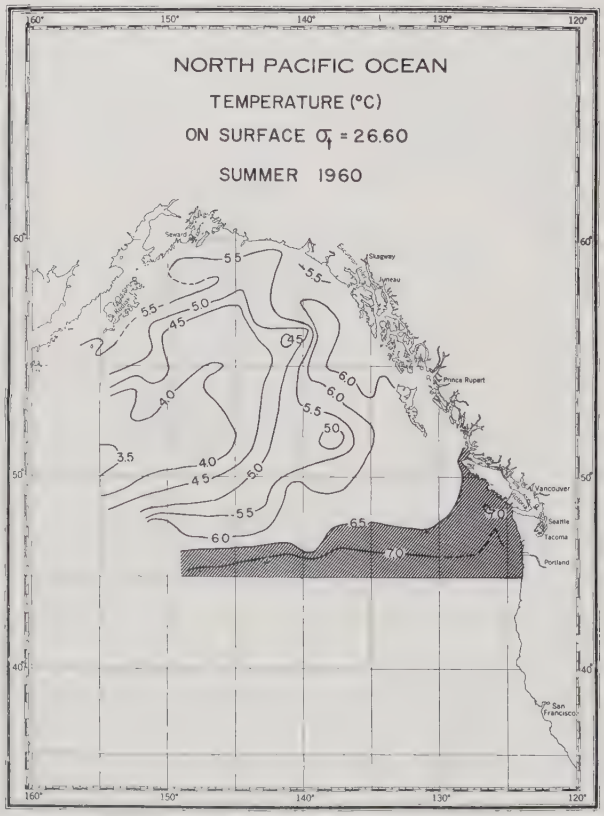


FIGURE 21.



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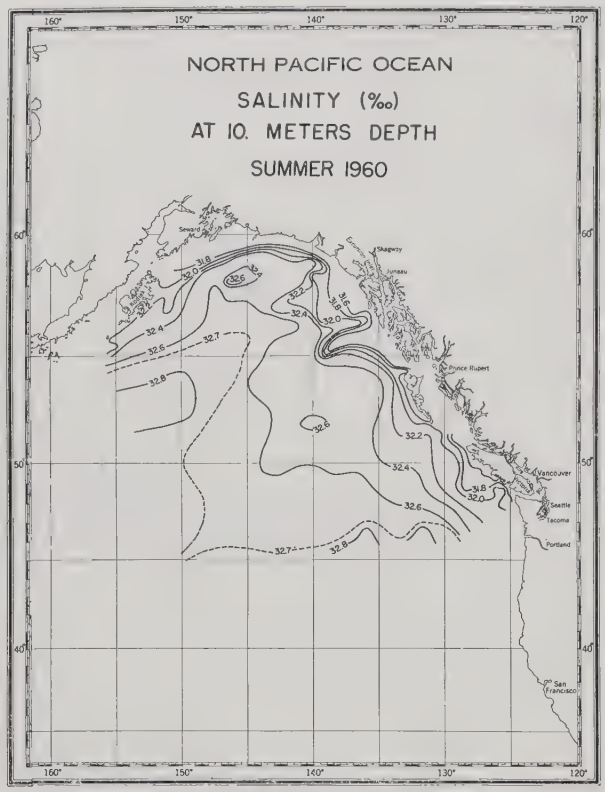

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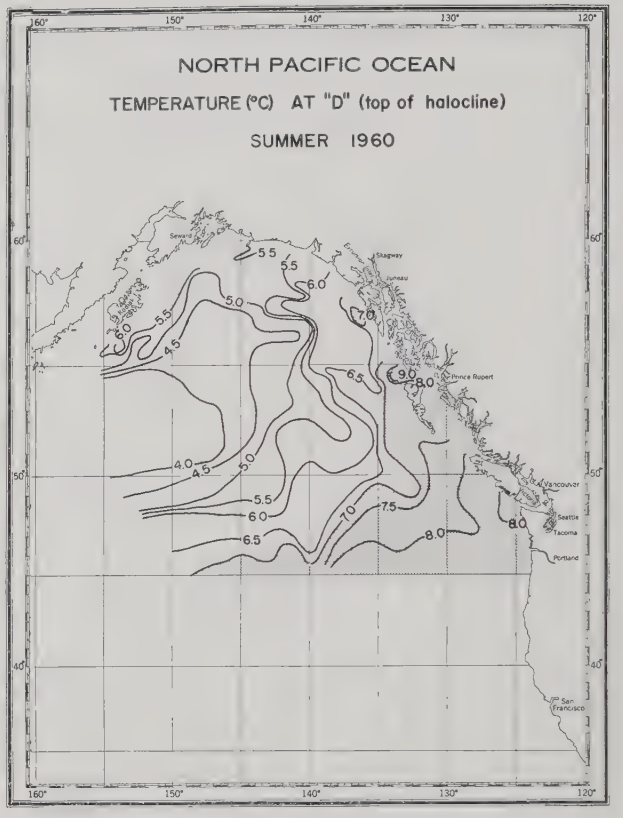

FIGURE 26.

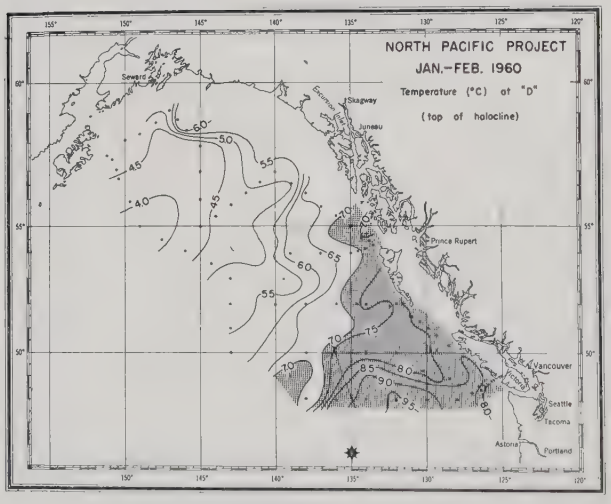

FIGURE 25.

ly associated with water from the Alaskan gyre, was present.

The distribution of temperature on the surface at which density=1.02660 (σ_t=26.60) has been used in earlier reports to show the intrusion of warm water along the British Columbia coast below the level of seasonal influence. The temperature distribution on this surface during the winter of 1960, and the differences compared to the winter of 1959, are shown in Figures 18 and 19 respectively. The areas of the temperature anomalies generally agree with those at 10 metres depth (Fig. 16) and are of the same order of magnitude except in the Gulf of Alaska. Thus the intrusions of water mentioned previously are not limited to the upper zone but persist at least to the intermediate waters (100–200 metres).

July-September, 1960. This preliminary assessment is made from data collected during an oceanographic cruise (July 28 to September 6, 1960) using two vessels, C.N.A.V. *Oshawa* and *Whitethroat.*

The observed temperature distributions at 10 metres depth during summers 1959 and 1960 are very similar (Fig. 20 and 21 respectively). Slightly colder water was present westward of Queen Charlotte Sound in 1960. Relatively cold water apparently intruded from the west, resulting in a discontinuity in the 13° C. isotherm.

The temperature distribution during these two periods on the surface σ_t=26.60 are also similar; in particular, the location of the 6.5°C. isotherm (Fig. 22 and 23). Warm (6.0°C.) water in the form of a tongue

did extend further northward in 1960.

In 1959 there were two marked intrusions in the Gulf of Alaska outlined by the 4.0 and 5.0°C. isotherms, resulting in a marked gradient in the temperature distribution at this level. These movements apparently relaxed during 1960 as shown by the gradual change in temperature in these regions.

It can be concluded that with conditions very similar in the seasonal (10 metres) and non-seasonal zones (σ_t=26.60) layers, the distribution of water masses and their movements, at least in the upper 200 metres, were similar for these two periods, except for the two marked intrusions discussed above. Data from Station " P " and the coastal lightstations suggest that these periods represent near-average conditions.

The salinity distribution at 10 metres depth (Fig. 24) is also similar to that observed last summer. However, compared to the previous winter (Fig. 17) it is noted that relatively fresh water (less than 32.4‰) extended further offshore in summer. This feature is primarily related to the presence of a marked thermocline in summer, whose stability conserves fresh water in the surface zone (10–30 metres depth).

In Figures 25 and 26 are presented the temperature distributions at depth " D " (top of halocline) from winter and summer, 1960. They are quite similar in their distribution. This is further evidence that the winter temperatures of the upper zone can be recognized in the following summer's data.

B. Circulation and Transport in the North Pacific Ocean

Circulation calculated from oceanographic observations. The principal features of the circulation are summarized from the calculated currents presented in Figures 27 to 30.

(a) A mid-ocean movement from the west and toward the North American coast at a rate of about 2 miles per day (4 cm/sec).

(b) A division of this flow near the coast; part moving northeast and circulating around the Gulf of Alaska. The other part turns southward to form the California Current system, resulting in a region of divergence.

(c) The part that moves into and around the Gulf of Alaska continues westward along the Aleutian Islands. Most of this water moves into the Bering Sea, through and at the end of the Aleutian Islands. There is some evidence for a return flow south of the Aleutian Islands.

(d) In the Bering Sea most of the water continues in a counter-clockwise circulation around the Bering Sea, then flows southward and either re-circulates in a counter-clockwise gyre off the coast of Kamchatka, or moves eastward in the mid-ocean region.

Drift-bottle returns confirm some of these features. Examples are shown in Figures 31 and 32.

Wind-induced circulation in the North Pacific Ocean. The main features of the circulation in the North Pacific Ocean have been established for a long time. Recently we have seen marked changes in the strength and distribution of currents. It is desirable to explain and

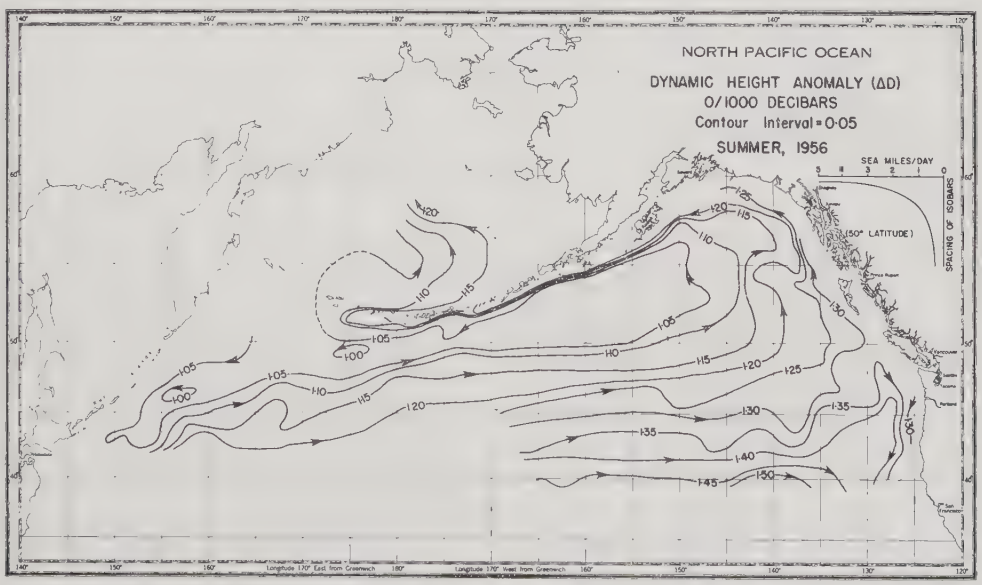

FIGURE 27.

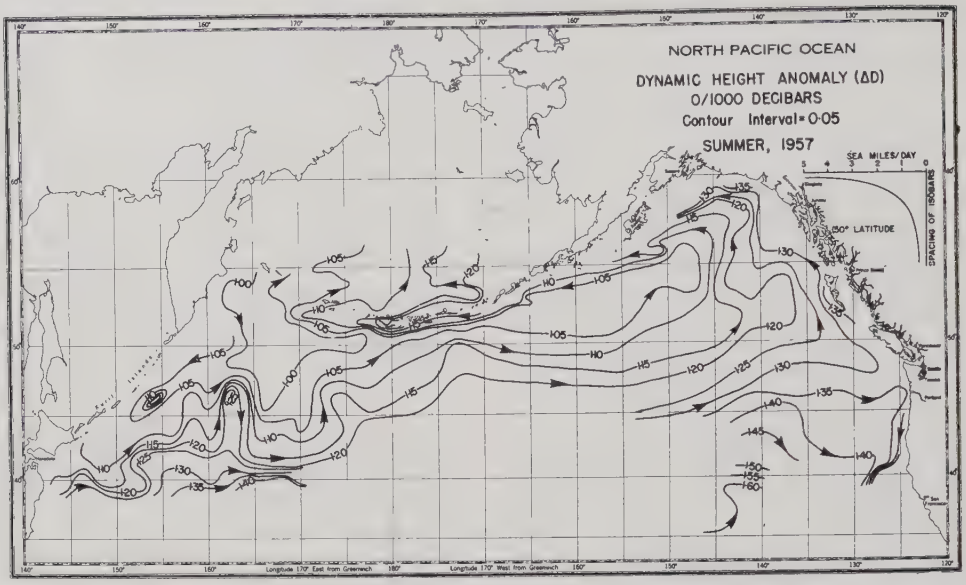

FIGURE 28.

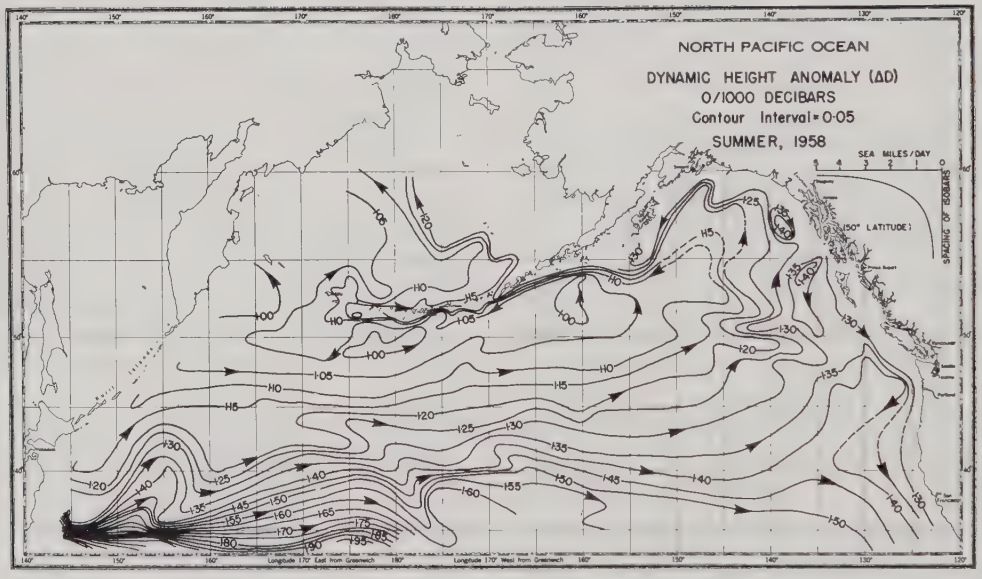

FIGURE 29.

eventually to predict these changes.

Physicists studying the ocean have shown that the total transport of mass (circulation) depends primarily on the curl of the wind stress components acting on the surface of the ocean. Computations based on this theoretical study have yielded transports which agree quite well with the distribution and magnitude of transports calculated from oceanographic observations thus confirming the validity of the method.

The circulation which would result from the mean monthly barometric pressure distribution if it continued until equilibrium was reached, has now been computed for each month from January, 1955, to the present. These calculations were undertaken to gain some idea of the variability, both with place and time, of the transport that is imposed on the ocean by the atmosphere. The calculations have been published in the form of monthly and mean charts and it is planned to keep these calculations up to date and to publish them at the end of each year.

It is realized that much study is required to evaluate this method of computing ocean circulations. However, the study has opened up a large source of information describing the driving forces in the ocean

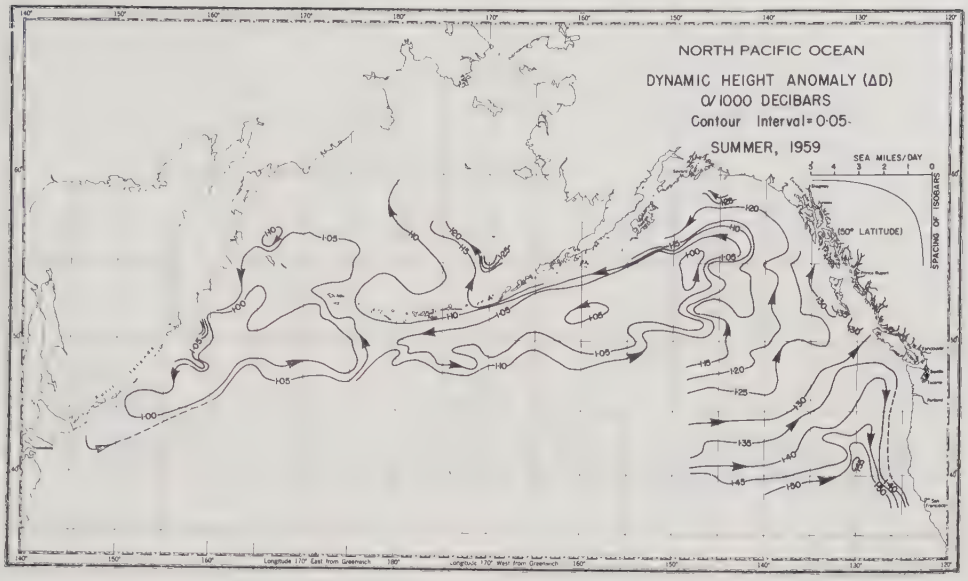

FIGURE 30.

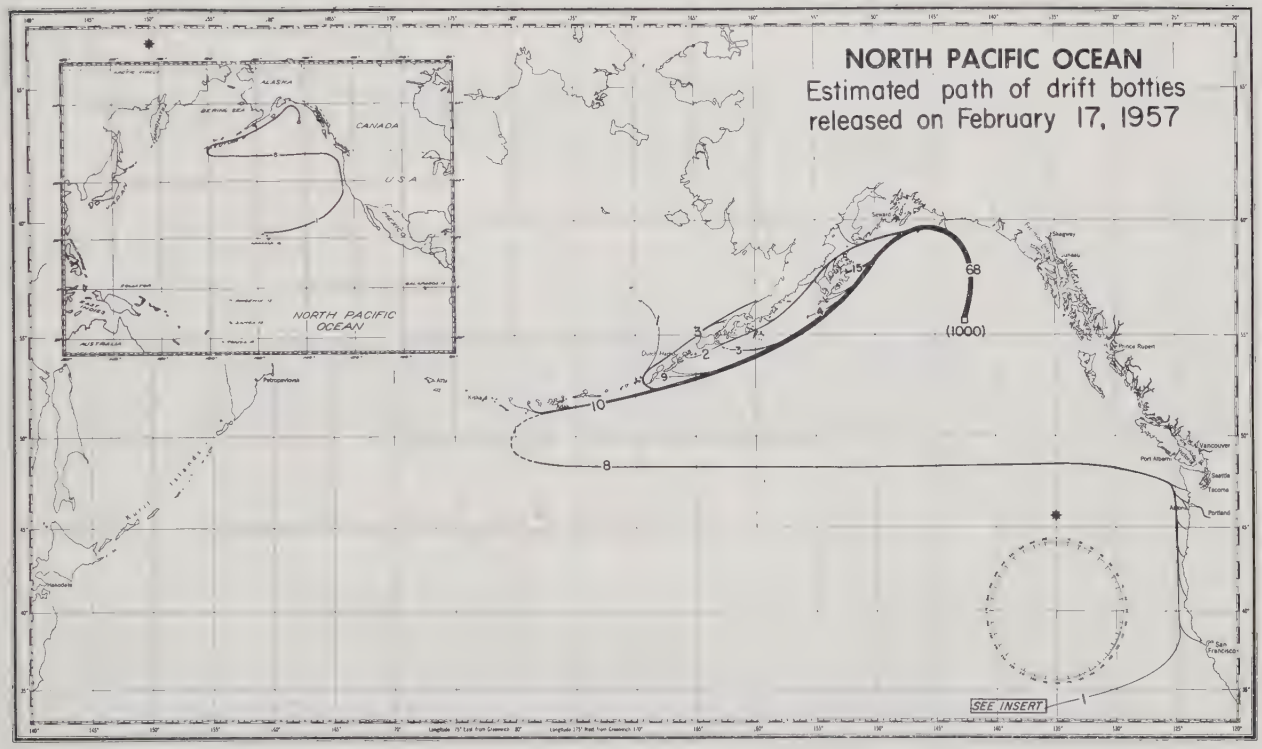

FIGURE 31.

that was not previously available in useable form.

Growth and decay of the thermocline at Ocean Weather Station " P ". In the sub-arctic Pacific Ocean it has been observed that the waters are virtually isothermal to the top of the halocline (about 100 metres) at the end of the cooling season in late March. With the advent of the heating season in April a thermocline is formed. It is overlaid by a nearly isothermal (mixed) layer which continues to warm through the heating season until the end of August. Below it there is an unwarmed layer which has been shown to be the remnant of the previous winter structure. Hence, the thermocline grows in a depth interval which at Station " P " is between 20 and 60 metres.

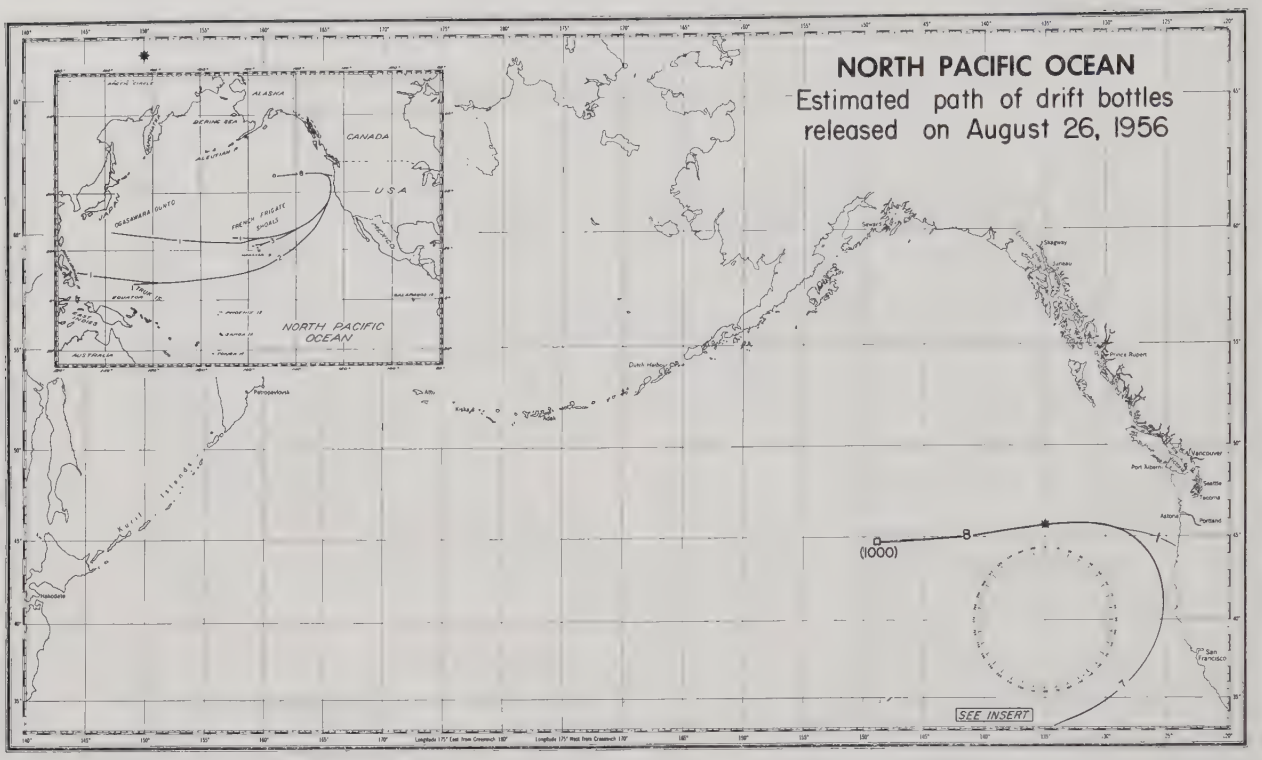

FIGURE 32.

During the cooling season, from September, the surface mixed layer cools and deepens. The thermocline becomes ever more abrupt, deepens, and decays and may vanish in late February. The growth and decay of the thermocline is illustrated in Figure 33.

The mechanics of the growth and decay of the thermocline are being studied in the semi-daily bathythermograph observations at Ocean Station " P " (Lat. 50° N., Long. 145° W.). As the mechanics are similar in all oceanic areas, differing only in degree from place to place and time to time, it is convenient to summarize some of the principal conclusions.

In the oceanic regions (away from the coasts) three dominant processes are involved in the growth and decay of the thermocline—heating, cooling, and wind mixing. Heating is due to radiant energy from the sun and occurs only during daylight hours. Cooling is due to evaporation, radiation and conduction of heat from the sea surface, and is continuous day and night. There is a net heat gain from April to September at Station " P " and a net loss through the winter cooling season. The winds exist at all times and provide a mixing force where depth of influence varies with the wind speed.

The surface waters are warmed whenever the daytime heating exceeds the continuous cooling process.

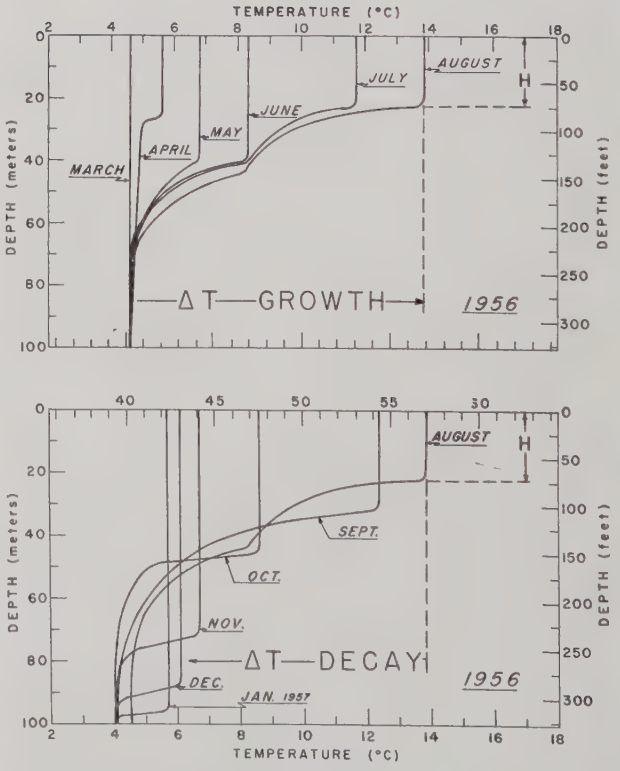

FIGURE 33. Growth and decay of thermocline, Ocean Station " P " (Lat. 50°N. ; Long. 145°W.).

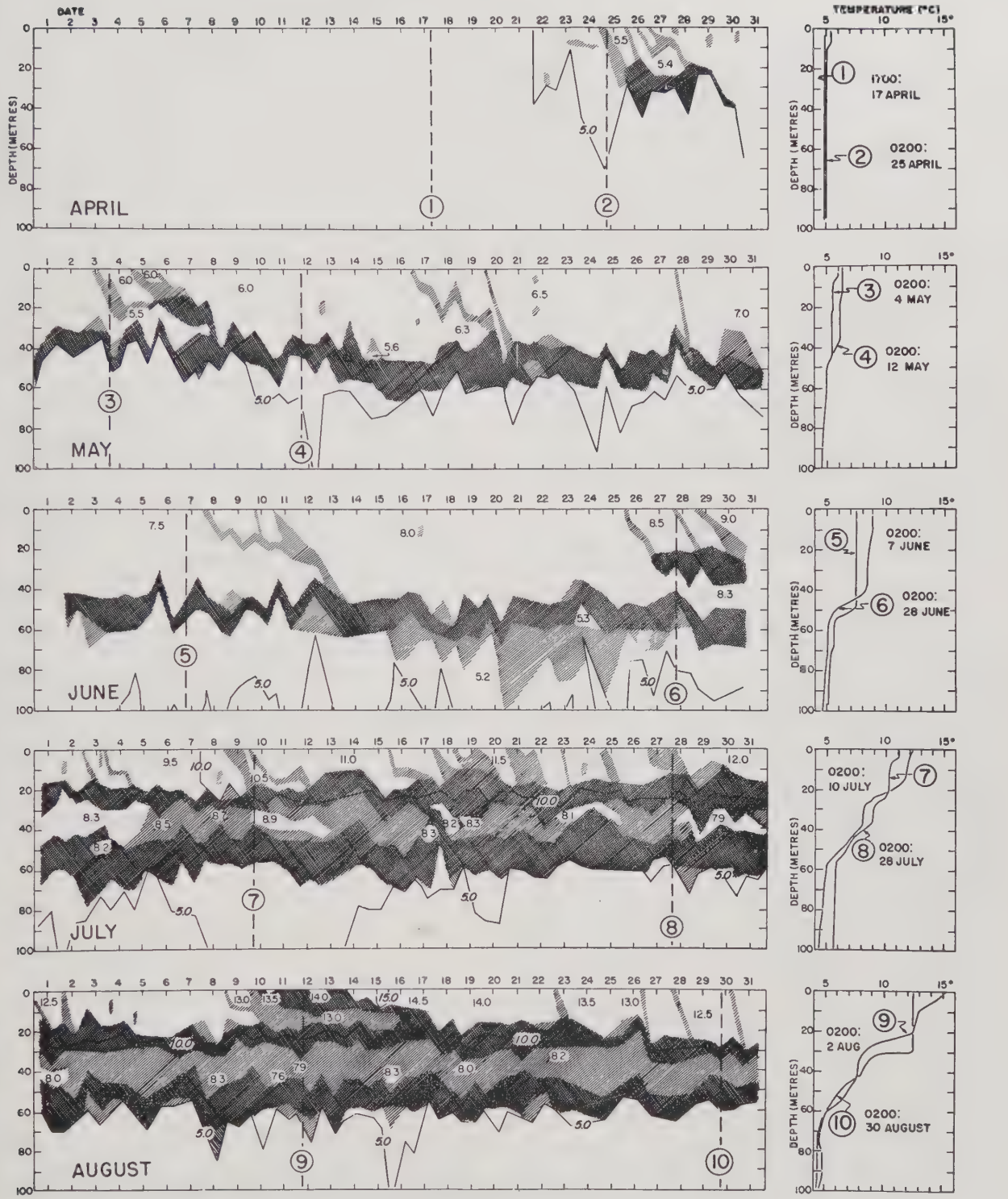

FIGURE 34. Features of the thermocline, Ocean Weather Station "P", 1956.

Usually, there is some wind so that a shallow (1–5 m.) mixed layer is formed. Below this is a small thermocline separating the warmed surface waters from the deeper waters. The heat and the associated thermocline may vanish if the night-time cooling exceeds the daytime heating. In this stage the thermocline is transient. If the heat is not lost it is mixed downward by the continuing wind, to the limiting depth of

wind influence. There, the thermocline becomes stable.

These processes are illustrated in Figure 34. The positions of the stable thermoclines are shown by cross hatching. The positions of the transient thermoclines as functions of time are shown by shaded transients through the mixed layer above the shallowest stable thermocline. The transients first occurred in April, and a stable thermocline was formed at the end of the month. Thereafter, the transients occurred with increasing frequency throughout the heating season. Each transient provided a small increase in the temperature of the mixed layer, and added to the magnitude of the stable thermocline.

Aside from oscillation because of internal waves the stable thermocline cannot ascend toward the surface. However, the mixed layer can deepen in the presence of any process which will increase the mixing, or remove the heat.

One sequence of events is illustrated in Figure 34. The stable thermocline deepened through May. Then, at the end of June, in a period of light winds a second thermocline was formed, overlying the old one. Thereafter, all heat additions (transients) contributed to this second thermocline while the old thermocline remained constant. During a period of very light winds, the thermocline may find an even shallower depth of stability, so that a third thermocline may form. This occurred during August 9 to 17. However, as soon as the winds increased this descended to the next level and joined the second thermocline. Evidently the mean depth of the mixed layer is a measure of the maximum winds that have occurred since the level was established. Further, each thermocline forms a cover protecting the water below it from further heating from the suface.

At the end of the heating season two processes, cooling and increased wind mixing, become dominant. With the increasing autumnal winds there is a further redistribution of heat and modification of structure. The warmed waters, in the erstwhile shallow mixed layer, are mixed with the cooler waters in the thermocline. In consequence the mixed layer deepens and becomes truly isothermal; the thermocline becomes thinner, and its temperature gradient becomes abrupt (Fig. 33). This process is intermittent with the occurrence of storms. Also, during the cooling season there is a net heat loss from the surface. Because the mixed layer is truly isopycnal convection currents occur. Hence the cooling is uniform throughout the mixed layer. This continuous process can only increase the depth of the mixed layer by erosion of the thermocline. The two processes act together to increase the mixed layer and cool the water in the mixed layer, thus reducing the thermocline as shown in the second diagram of Figure 33.

In the limit, at the end of the cooling season, the mixed layer extends to some recognizable depth. It may be colder, have the same temperature, or be warmer than the underlying waters. Thereafter the cycle is repeated as a new thermocline is formed near the surface next summer. When this occurs the remnants of the winter thermal structure are protected from any further local heat input from the surface. Hence this limit of winter cooling is the limit of seasonal surface influence. In the sub-arctic region the limit of the process is the top of the halocline.

B. REPORT ON THE RESEARCH BY JAPAN FOR THE INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION DURING THE YEAR 1960

Fisheries Agency of Japan
February, 1961

I. SALMON

Introduction

As a result of the joint investigations conducted during the past five years, we now have a fairly good knowledge of the general characteristics of the distribution, migration and intermingling of salmon in the offshore waters of the North Pacific Ocean. More than one generation of salmon has been under our observation, and it is hoped that the study of cyclic fluctuations of these generations will lead to firmer conclusions regarding some phases of the research.

In 1960, Japan attempted to intensify tagging experiments. Other types of studies were also conducted on a scale comparable to past years.

Analysis of the data collected is in progress in the various fields; certain portions of such studies have been incorporated in the work of joint reporting by the Commission.

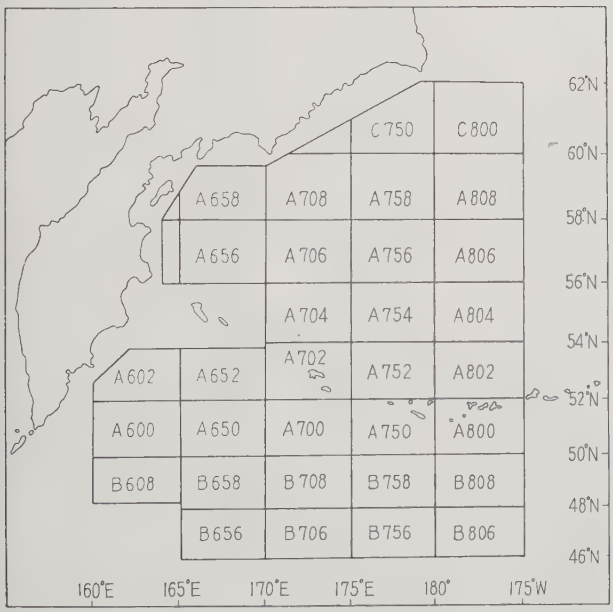

Figure 1. Statistical areas for the mothership salmon fishery, 1960.

1. Offshore Distribution of Salmon

A. Collection and Analysis of Data from Commercial Catches

Table 1 gives the statistics of the salmon catch by the Japanese mothership fishery in Aleutian waters by species, by ten-day period and by area. The statistical areas used in Table 1 are shown in Figure 1. Table 1 also shows the cumulative amount of gear used.

B. Study of Offshore Distribution by Research Vessels

The *Etsuzan-maru* (150 g.t., 320 h.p.) was chartered as a government research vessel for this purpose. The *Etsuzan-maru* left Hakodate on May 16 and operated in the waters south and north of the Aleutian chain during the period from May 28 to June 29, studying the distribution principally of sockeye and chum salmon and collecting samples. She entered Hakodate on July 6 and sailed again from Yoichi on July 17. In her second cruise, the *Etsuzan-maru* operated in the Okhotsk Sea and Bering and Aleutian waters west of 175° E. during the period from July 20 to August 18 and studied the distribution of immature salmon.

Figure 2 shows the stations occupied by the *Etsuzan-maru* in her first and second cruises. The records of catches by gillnet are given in Table 2, by mesh sizes. The *Etsuzan-maru* used, as a standard, four shackles of 2-1/2 inch nets, four shackles of 3-1/4 inch nets, twelve shackles of 4-1/2 inch nets, four shackles of 5-1/4 inch nets and 60 tans (one tan measures 180 feet) of 4.8 inch nets at each station. As many fish as possible were processed aboard the research vessel for measurement and sampling of scales and other materials; the remainder of the fish were frozen and brought back to the Yoichi Laboratory, where they were measured and sampled. Most of the fish brought back to the laboratory had been taken by 4.8 inch nets during the

TABLE 1. Catch statistics of the mothership salmon fishery in Aleutian waters in 1960. (Numbers of fish caught by species, ten-day periods and areas of 2°×5° each[1]).

Period	Area	Species						Cumulative quantity of gear used (in tans)
		Sockeye	Chum	Pink	Coho	Chinook	Total	
	A652	13,607	41,492	3,823	—	105	59,027	9,944
	A650	290,392	295,480	14,407	—	373	600,652	138,872
May 21—	B658	360,133	316,531	7,960	—	314	684,938	177,057
	B656	261,115	181,916	15,509	9	90	458,639	150,023
May 31	A702	14,223	28,848	2,410	—	72	45,553	11,066
	A700	104,399	117,217	13,670	—	238	235,524	68,419
	B708	89,669	66,491	1,669	—	59	157,888	42,725
	Sub-total	1,133,538	1,047,975	59,448	9	1,251	2,242,221	598,106
	A602	72,840	60,573	4,018	—	86	137,517	50,383
	A600	5,980	8,557	78	—	12	14,627	7,942
	B608	85,224	276,780	121,590	—	308	483,902	75,595
	A652	144,068	175,298	15,144	—	214	334,724	110,153
June 1—	A650	221,168	147,051	14,847	—	354	383,420	144,457
	B658	29,466	26,614	2,934	—	53	59,067	19,062
June 10	B656	55,078	34,378	17,066	51	50	106,623	33,462
	A702	64,282	73,580	8,961	—	91	146,914	50,457
	A700	286,978	326,958	27,053	3	316	641,308	261,071
	A752	117,180	138,135	15,741	—	469	271,525	55,683
	A750	198,979	95,740	4,074	—	260	299,053	76,904
	Sub-total	1,281,243	1,363,664	231,506	54	2,213	2,878,680	885,169
	A602	30,611	60,483	19,497	—	240	110,831	24,597
	A600	70,499	255,665	114,735	3	442	441,344	84,517
	B608	40,182	140,049	61,692	3	192	242,118	32,828
	A652	17,834	41,323	18,201	—	202	77,560	16,992
	A650	67,741	67,429	18,681	—	83	153,934	48,104
	B658	34,320	30,121	4,096	—	84	68,621	19,454
June 11—	B656	17,573	8,348	3,849	6	8	29,784	8,703
	A702	57,839	73,439	16,726	—	119	148,123	43,765
June 20	A754	45,179	99,532	14,660	—	324	159,695	34,586
	A752	168,002	179,355	19,257	1	1,830	368,445	87,798
	A750	334,044	61,683	5,051	—	400	401,178	84,515
	A806	63,120	237,290	25,227	—	4,726	330,363	58,459
	A804	529,825	393,914	51,386	1	7,531	982,657	204,395
	A802	935,194	240,350	22,373	2	3,741	1,201,660	198,558
	A800	136,638	20,791	1,577	—	106	159,112	38,487
	Sub-total	2,548,601	1,909,772	397,008	16	20,028	4,875,425	985,758
	A658	17,599	75,191	109,958	—	3,209	205,957	37,349
	A656	11,114	37,171	80,974	—	2,977	132,236	27,558
	A652	33,290	38,795	11,665	9	239	83,998	24,090
	A650	48,591	45,992	6,604	149	148	101,484	24,419
	B658	96,507	62,873	8,721	462	240	168,803	42,175
June 21—	A708	47,573	219,593	108,780	8	10,839	386,793	125,738
	C750	9,936	89,077	15,341	—	2,779	117,133	29,443
June 30	A758	15,141	86,193	32,086	—	6,780	140,200	40,722
	A756	10,623	21,419	6,665	2	2,587	41,296	23,559
	A750	44,147	44,032	1,363	29	92	89,663	23,702
	C800	31,507	102,318	8,460	—	703	142,988	48,387
	A808	232,657	609,947	73,038	2	49,398	965,042	217,927
	A806	82,031	193,197	24,387	—	16,292	315,907	80,262

Continued.....

TABLE 1. (continued)

Period	Area	Species						Cumulative quantity of gear used (in tans)
		Sockeye	Chum	Pink	Coho	Chinook	Total	
	A804	308,337	160,212	17,113	—	6,693	492,355	124,004
	A802	265,281	138,416	8,942	6	2,039	414,684	101,742
	Sub-total	1,254,334	1,924,426	514,097	667	105,015	3,798,539	971,077
	A602	176,167	157,909	43,414	696	658	378,871	92,764
	A600	382,309	251,164	31,060	2,286	1,095	667,914	158,056
	B608	347,759	430,706	36,132	10,851	2,408	827,856	136,166
	A658	42,438	126,390	164,078	—	1,560	334,466	46,708
July 1—	A656	23,673	39,578	166,312	—	1,225	230,788	28,003
	A652	150,196	125,103	31,817	712	648	308,476	72,530
July 10	A650	179,098	163,483	16,641	1,385	777	361,384	75,329
	B658	519,804	407,894	22,508	12,160	1,928	964,294	168,169
	A808	59,827	332,527	19,709	2	10,007	422,072	85,204
	A806	23,257	283,851	12,350	5	5,803	325,266	62,636
	Sub-total	1,904,528	2,318,605	544,021	28,097	26,136	4,821,387	925,565
	A602	55,860	78,481	2,121	897	79	137,438	24,202
	A600	171,515	133,229	3,961	5,806	533	315,044	74,569
	B608	382,091	217,979	13,870	20,569	1,143	635,652	154,746
	A658	8,414	18,111	12,896	—	155	39,576	7,654
July 11—	A652	341,974	228,096	12,226	9,184	1,250	592,730	129,966
	A650	595,848	376,551	14,936	23,179	1,838	1,012,352	244,990
July 20	B658	908,905	227,219	23,779	77,722	1,375	1,239,000	269,072
	B656	4,301	7,729	2,247	37,112	993	52,382	22,440
	A700	16,137	9,291	74	2,282	—	27,784	8,252
	B708	105	2,664	201	23,948	674	27,592	9,898
	B706	28,204	29,594	4,489	114,675	5,373	182,335	74,734
	Sub-total	2,513,354	1,328,944	90,800	315,374	13,413	4,261,885	1,020,523
	A600	69,272	23,220	844	6,163	171	99,670	36,680
	B608	379,831	196,172	20,266	66,383	1,166	663,818	177,529
	A652	63,702	27,201	780	3,544	171	95,398	32,529
July 21—	A650	267,171	51,501	2,649	26,539	556	348,416	115,443
	B658	537,356	69,237	8,523	122,280	1,396	738,792	239,854
July 31	B656	21,233	7,093	12	5,574	340	34,252	10,560
	A700	259,204	44,648	4,444	44,278	658	353,232	119,565
	B708	194,259	65,186	2,411	155,184	3,174	420,214	143,687
	B706	92,189	50,959	1,076	164,797	3,614	312,635	124,240
	Sub-total	1,884,217	535,217	41,005	594,742	11,246	3,066,427	1,000,087
	A600	95,788	30,894	525	6,523	342	134,072	37,856
	B608	167	10,938	3,722	4,561	382	19,770	7,564
August 1—	A652	26,703	2,036	41	171	—	28,951	8,448
	B658	21,339	4,319	115	1,701	154	27,628	9,097
August 10	A702	189,886	36,189	2,978	8,151	147	237,351	61,210
	A700	25,209	4,228	114	1,887	33	31,471	8,071
	Sub-total	359,092	88,604	7,495	22,994	1,058	479,243	132,246
GRAND TOTAL		12,878,907	10,517,207	1,885,380	961,953	180,360	26,423,807	6,518,531

[1] For areas, see Figure 1.

TABLE 2. Catch records of the

Date	Position		Surface temp. °C.	No. of tans					Sockeye				
				2½″	3¼″	4½″	5¼″	4.8″	2½″	3¼″	4½″	5¼″	4.8″
5.28	49-49.0N	170-34.0W	4.4	4	4	12	4	60	—	5	42	4	66
5.29	50-00.0N	172-30.0W	4.8	4	4	12	4	60	—	5	58	7	54
5.30	50-00.0N	175-00.0W	4.6	4	4	12	4	59	—	2	13	3	28
5.31	50-00.0N	177-30.0W	4.9	4	4	11	3	60	—	1	20	7	29
6.1	50-00.0N	180-00	5.1	4	4	12	4	60	—	1	13	3	21
6.3	50-00.0N	175-00.0E	4.7	4	4	12	4	—	—	1	13	7	—
6.4	50-00.0N	172-30.0E	5.1	4	4	12	4	60	2	2	25	14	44
6.6	48-00.0N	168-00.0E	3.7	4	4	12	4	60	1	1	28	4	12
6.7	49-20.0N	168-00.0E	4.5	4	4	12	4	60	—	—	7	1	9
6.8	51-00.0N	168-00.0E	4.9	4	4	12	4	60	—	4	17	11	29
6.9	52-40.0N	168-00.0E	4.8	4	4	12	4	60	—	2	29	18	27
6.10	54-06.5N	169-43.0E	4.25	4	4	12	4	60	4	—	22	4	46
6.11	53-38.0N	173-47.0E	5.4	4	4	12	4	60	—	1	3	2	21
6.12	52-55.0N	176-49.0E	5.6	4	4	12	4	60	—	—	25	5	22
6.15	53-00.0N	175-00.0W	5.3	4	4	12	4	60	2	2	58	15	91
6.16	53-00.0N	175-00.0W	5.2	4	4	12	4	23			356		172
6.17	53-00.5N	172-27.0W	5.5	4	4	12	4	60	7	6	158	34	285
6.18	53-15.0N	170-00.0W	5.5	4	4	12	4	60	13	34	162	39	173
6.19	54-41.2N	170-05.0W	6.2	4	4	12	4	60	22	34	165	45	287
6.20	56-00.0N	170-00.0W	6.2	—	—	—	—	60	—	—	—	—	162
6.21	56-00.0N	172-32.0W	6.0	4	4	12	4	60	16	5	88	39	171
6.22	55-55.0N	175-02.0W	6.2	4	4	12	4	60	3	5	44	11	86
6.24	54-56.0N	179-54.0E	5.6	4	4	12	4	60	2	—	18	5	35
6.25	56-00.0N	177-30.0E	5.8	4	4	12	4	60	—	—	7	6	8
6.27	56-00.0N	172-30.0E	6.3	4	4	12	4	60	1	5	10	6	17
6.28	57-02.5N	169-50.0E	7.0	4	4	12	4	60	1	—	5	4	7
6.29	54-51.0N	169-08.0E	6.4	3	3	11	3	60	—	—	9	4	16
7.20	47-08.5N	149-50.0E	8.6	3	3	9	3	60	—	—	—	—	1
7.21	47-53.5N	151-19.5E	8.2	3	3	9	3	60	—	—	—	—	1
7.22	49-32.0N	153.16.5E	6.7	3	3	9	3	60	—	—	17	9	49
7.26	55-24.0N	163-50.0E	9.5	3	3	9	3	60	32	65	55	4	50
7.27	56-59.0N	164-59.0E	10.5	3	3	9	3	60	3	13	30	4	27
7.28	58-29.0N	167-30.0E	10.5	3	3	9	3	60	7	31	56	1	63
7.29	59-00.0N	170-00.0E	9.0	3	3	9	3	60	6	17	75	3	35
7.30	59-00.0N	172-30.0E	9.4	4	4	12	4	60	6	10	52	5	30
7.31	57-30.0N	172-30.0E	9.5	4	4	12	4	60	4	8	35	3	22
8.1	57-30.0N	170-00.0E	9.6	3	3	9	3	60	2	11	28	3	35
8.2	57-30.0N	167-30.0E	10.5	—	—	—	—	60	—	—	—	—	37
8.3	56-00.0N	167-30.0E	10.8	3	3	9	3	60	—	2	1	—	4
8.4	56-00.0N	170-00.0E	10.8	3	3	9	3	60	11	21	13	3	44
8.5	56-00.0N	172-30.0E	10.4	4	4	12	4	60	2	5	31	2	19
8.6	54-30.0N	172-30.0E	10.4	3	3	9	4	60	1	2	21	2	20
8.8	54-43.0N	170-12.0E	10.0	3	3	9	3	—	—	1	36	—	—
8.9	53-36.5N	167-41.0E	10.6	3	3	9	3	60	2	8	39	2	30
8.10	53-30.0N	165-00.0E	11.5	3	3	9	3	60	1	7	78	5	55
8.11	53-30.0N	162-30.0E	11.6	4	4	12	4	60	4	5	24	4	35
8.12	52-00.0N	162-29.0E	12.0	—	—	—	—	60	—	—	—	—	55
8.14	52-00.0N	165-00.0E	11.5	4	4	12	4	—	—	6	97	5	—
8.15	52-00.0N	167-30.0E	11.0	4	4	12	4	—	—	1	14	2	—
8.16	52-00.0N	169-30.0E	10.4	4	4	12	4	—	3	10	45	2	—
8.17	50-31.5N	170-04.0E	10.5	4	4	12	4	—	—	1	13	1	—
8.18	50-30.0N	167-30.0E	10.8	4	4	12	4	60	1	1	9	2	6

Etsuzan-maru. First cruise, May 28–June 29; Second cruise, July 20–August 18.

Chum					Pink					Coho					Chinook				
2½″	3¼″	4½″	5¼″	4.8″	2½″	3¼″	4½″	5¼″	4.8″	2½″	3¼″	4½″	5¼″	4.8″	2½″	3¼″	4½″	5¼″	4.8″
—	1	18	3	23	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
—	1	27	9	21	—	15	7	—	2	—	—	—	—	—	—	—	—	—	—
—	—	5	3	9	—	3	4	—	3	—	—	—	—	—	—	—	—	—	—
—	—	19	1	22	—	3	3	—	—	—	—	—	—	—	—	—	—	1	—
—	—	28	4	64	—	10	4	—	1	—	—	—	—	—	—	—	—	—	—
—	—	36	3	—	—	12	3		—	—	—	—	—	—	—	—	—	—	
—	—	33	3	57	—	8	2	—	2	—	—	—	—	—	—	—	1	1	—
—	—	4	4	8	—	3	2		—	—	—	—	—				—	—	—
—	—	7	—	12	—	2	5	—	—								—	—	—
—	—	18	5	21	—	4	13	—	1	—	—	—	—		—			—	
—	3	46	9	28	—	14	27	—	3	—	—	—	—	—	—		—	—	—
—	1	31	17	80	—	6	5	—	1	—	—	—	—	—	—	—	—	2	—
—	2	56	17	34	—	11	6	—	6	—	—	—	—	—	—	—	1	3	1
—	—	4	—	3	—	5	3	—	—	—	—	—	—	—	—	—	—	—	—
—	—	8	3	16	—	1	—	—	—	—	—			—	—		—		—
		14		5			5		3	—	—	—	—	—			—	—	—
—	—	8	1	15	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—
1	—	33	13	29	—	—	4	—	1	—	—	—	—	—	—	—	—		—
—	6	8	7	27	—	3	3	—	1	—	—	—	—	—	—	—	1	1	2
—	—	—	—	54	—	—		—	—		—	—	—		—	—	—	—	
—	1	6	—	6	—	1	3	1	1	—	—	—	—	—	—	—	—	—	1
—	1	37	4	35	—	3	20	—	4	—	—	—	—	—	—	5	—	1	2
—	—	20	4	13	—	1	2	—	—	—	—	—	—	—	—	—	1	—	—
—	1	14	—	15	—	7	12	2	6	—	—	—	—	—	—	—	—	—	—
1	—	35	1	22	—	10	42	—	9	—	—	—	—	—	—	—	—	1	—
—	2	12	9	16	—	4	48	—	20	—	—	—	—	—	—	2	7	1	—
—	2	10	1	6	—	6	17	2	6	—	—	—	—		—	—	—	—	—
—	—	17	9	45	—	1	34	10	109	—	—	1	—	6	—	—	—	—	1
—	1	17	8	51	1	3	89	11	215	—	—	2	—	3	—				—
—	2	35	10	48	—	2	74	20	100	1	—	4	1	8				—	
8	25	17	6	28	—	—	1	1	—	1	—	1	1	—	—	—	1	—	—
17	38	78	8	67	—	—	1	—	6	—	—	—	1		—	—	—		
24	23	69	9	74	—	—	1	—	—	—	—	1	—	1			—	—	—
25	9	92	8	112	—	—	1	—	1	—	—	—	—	—	—	—	—	1	—
54	73	116	11	45			—		—		—		—	—	—	—	—	—	—
61	37	108	6	76	—	—	—	—	—	—	1	—	—	1	—	—	1	1	—
8	16	57	8	63	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—
—	—	—	—	35	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—
3	2	20	3	22	—	—	1	—	1	—	—	—	—	1	—	—	—	—	—
6	8	21	2	60	—	—	—	—	1	—	—	—	—	1	—	—	1	—	—
24	16	45	2	27	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—
5	9	42	3	32	—	—	—	—	—	—	—	1	—	—	—	—	1	—	1
—	2	15	4	—	—														
—	2	6	5	21	—	—	1	—	—	—	1	2	—	10	—	—	—	—	—
—	3	21	5	36	1	—	—	—	1	—	—	7	4	34	—	—	1	—	—
—	3	45	3	30	—	—	—	—	3	—	1	10	7	20		—	—	—	
—	—	—	—	43	—	—	—	—	1	—	—	—	—	11	—		—	—	
2	2	33	1	—	—	—	—	—	—	—	—	7	7	—	—	—	1	—	—
—	—	17	12	—	—	—	—	—	—	—	—	9	3	—	—	—	1	1	—
1	2	48	6	—	—	—	—	1	—	—	—	3	3	—	—	—	—	2	—
1	1	20	2	—	—	—	—	—	—	—	—	12	3		—	—			—
—	—	8	—	20	—	—	1	—	1	—	—	3	4	10	—	1	—	—	—

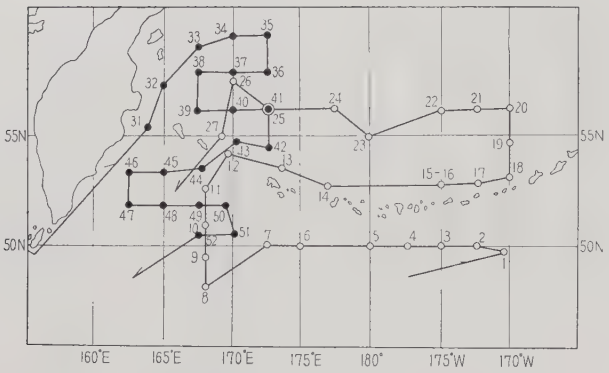

FIGURE 2. Cruise map and stations for the research vessel *Etsuzan-maru*, 1960.

○ 1st cruise ● 2nd cruise

second cruise; almost all of the other fish were processed aboard the research vessel. Samples were classified according to mesh sizes, with some exceptions.

Only age determination has been completed for the salmon which were collected by the *Etsuzan-maru* and measured and scale-sampled aboard the ship. The age composition of sockeye and chum salmon sampled in 1960 showed some interesting features. Corresponding to the great quantities of fish of age 4_2 in the Bristol Bay sockeye runs in 1956, large numbers of 4_2 sockeye of the 1956 year-class returned in 1960. Figure 3 shows the age composition of the sockeye caught by 4.8 inch nets during May and June. It

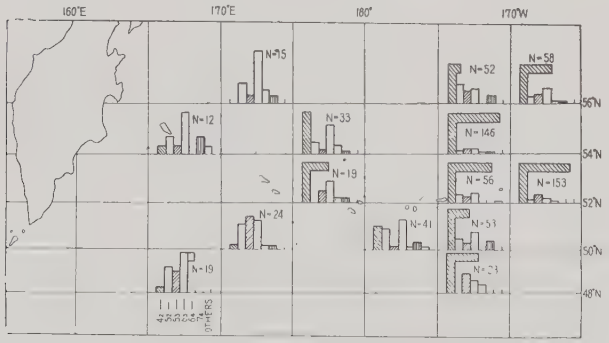

FIGURE 3. Age composition of sockeye salmon caught by the *Etsuzan-maru* with 4.8″ nets during May–June, 1960.

is noteworthy that very few 4_2 sockeye were found in the catches from waters west of 175° E.; fish of ages 6_3 and 5_2 constituted the main portions of the catches. The proportions of 4_2 fish became higher in the catches from waters between 175° E. and 180°. However, the proportions of fish of age 6_3 and some other age groups were also higher in these catches than the catches from waters farther eastward. Bering waters between 180° and 175° W. were not occupied by the research vessel because commercial fishing was active in this area.

The age composition of the chum salmon collected by the *Etsuzan-maru* with 4.8 inch nets during May and June is given in Figure 4. Corresponding to the dominance of 4-year old chums in 1959 in Asian waters, considerable quantities of 5-year old fish were

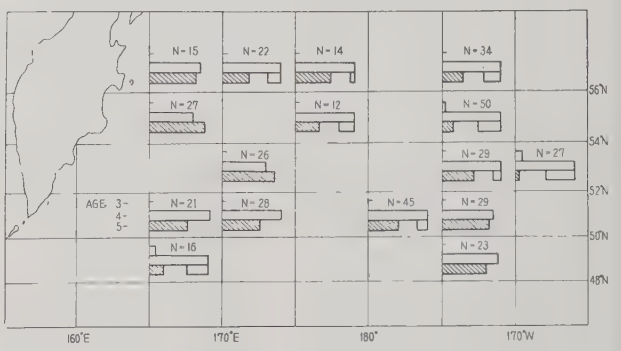

FIGURE 4. Age composition of chum salmon caught by the *Etsuzan-maru* with 4.8″ nets during May–June, 1960.

present in 1960. The proportion of 5-year old fish was somewhat smaller in waters south of the Aleutian chain than in the Bering Sea; and it tended to be lower eastward from 175° W. in the Bering Sea. Particularly the samples taken from the vicinity of 170° W.–52° N. consisted almost entirely of 4-year old fish. In this connection, it is interesting to note that the recoveries from chum salmon tagging in this particular area have been reported mostly from Alaska.

2. Studies for Distinguishing Stocks

Sockeye Salmon

Studies for distinguishing stocks by means of scales are being continued in 1960. Emphasis is placed on the distinction between the stocks of various districts of Asia. Analysis is now in progress.

Chum Salmon

Scale studies of chum salmon for distinguishing stocks are being continued. As in the case of sockeye, emphasis is placed on the distinction of different Asian stocks. An effort is being made to find regional characteristics in the scale pattern by measuring the scales obtained from the coasts and streams of the U.S.S.R. This work is now in progress.

Pink Salmon

Examination of new scale samples has not been conducted for this species. We are re-examining the data obtained during the past several years in the hope

of drawing more valid conclusions from the available data and improving future plans for the study of pink salmon.

3. Study of Movements by Tagging

In 1960, tagging experiments were conducted by two chartered vessels. The *Wakashio-maru* (153 g.t., 320 h.p.) operated in Aleutian waters, and the *Takuyo-maru* (172 g.t., 320 h.p.) covered waters south of 48° N. Their cruises and tagging locations are shown in Table 3 and Figure 5, respectively. The gear used was longlines, with specifications as given below. The specifications are almost the same as those of the longlines used in 1959, except that branch lines were made of synthetic material instead of cotton as used in 1959, and the longline floats used were made by cutting synthetic floats for salmon driftnets into two pieces instead of using glass balls of 4.8 inches in diameter as in 1959.

Table 3. Research cruises of *Wakashio-maru* and *Takuyo-maru*, 1960.

Name of vessel		Left Hakodate	Began investigation	Completed investigation	Entered Hakodate
Wakashio-maru	1st cruise	5–16	5–27	6–30	7–12
	2nd cruise	7–17	7–22	8–17	8–24
Takuyo-maru	1st cruise	5–7	5–8	5–28	5–30*
	2nd cruise	6–6*	6–8	6–29	7–8*
	3rd cruise	7–17*	7–27	8–1	8–18

* Kushiro.

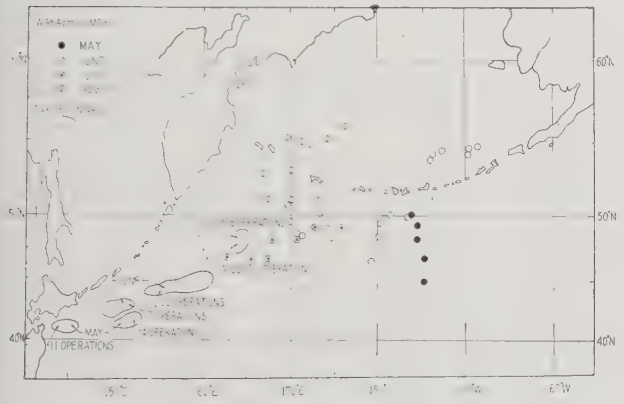

Figure 5. Tagging locations, 1960.

SPECIFICATIONS

MAIN LINES: Cotton #20; 72 threads; right-hand twist; total length 122.9 m.; finished length 122.4 m., with 25 cm. extra at each end.

BRANCH LINES: Synthetic line, 1.2 m. long; 50 lines per skate at intervals of 2.4 m. each.

HOOKS: Hooks used in commercial pink salmon fishing.

FLOATS: Salmon driftnet floats cut lengthwise into two pieces (5 per skate).

FLOAT-CONNECTING LINES: Cotton #20, 30 threads.

BASKETS: Round, flat bamboo basket, approximately 55 cm. in diameter.

As in past years, salted anchovy (*Engraulis japonicus* (Schlegel)) was used as bait. The length of the anchovies was 75–130 mm., average 97 mm., and the weight was 3.5–13 g., average 6.9 g.

Both disc tags and plastic tube tags were used. Disc tags were used principally, as suggested in the report by A. C. Hartt (at the 1959 INPFC Annual Meeting). In waters south of 48° N., however, tube tags were used during the early part of the season, because disc tags were not available when the vessel began the first cruise. The disc consisted of a piece of celluloid plate covered by plastic, the diameter and thickness of the plate being 14 mm. and 0.8 mm., respectively. It was red and white in color. The wire attached to the disc was 65 mm. long. The tube tag was made in Japan and harder than the similar tag made in the United States. The ink for writing letters and numbers did not penetrate too well, and it was feared that the letters and figures might disappear after a long period of time. Accordingly, a piece of orange celluloid plate, 10 mm. in diameter and 1 mm. in thickness, was attched to the tube to carry numbers and letters.

A total of 3,157 fish, most of which were relatively large, was tagged with disc tags; and 3,249 fish, most of which were relatively small, were tagged with tube tags. As of January 20, 1961, 106 disc tags have been returned from the 3,064 fish tagged in Aleutian waters, and no disc tags have been recovered from the 93 fish tagged in waters south of 48° N. No tube tags have been returned from the 369 fish tagged in Aleutian waters, and 66 tube tags have been returned from the 2,880 fish tagged in waters south of 48° N. The

above results should not be used to judge the relative usefulness of the two types of tags. The lack of recoveries of tube tags from tagging in Aleutian waters is owing to the fact that most of the fish tagged were small, as mentioned above. The lack of recoveries of disc tags from tagging in waters south of 48° N. is ascribed to the fact that disc tags were used during the latter half of the season in this region, when greater portions of the fish tagged were immatures and also the chances of recovery were very small, due to the absence of commercial fishing.

The tagging areas in 1960 may be divided into nine regions (see Figure 5 and Table 4). The numbers of mature and immature salmon tagged in each region

Table 4. Tagging by *Wakashio-maru* and *Takuyo-maru*, 1960.

	A	B	C	D	E	F	G	H	I	Total
Area of tagging	44N-51N 170E-175W	53N-55N 174W-169W	46N-49N 160E-175E	50N-53N 165E-175E	54N 56N 165E-175E	40N-41N 143E-145E	41N-42N 148E-153E	43N-45N 153E-160E	47N-48N 163E-164E	
Period	5.27-6.20	6.25-6.30	7.22-7.30	8.2-8.6	8.9-8.17	5.8-5.14	5.22-6.12	6.13-6.29	7.27-8.1	
No. of operations	18	6	7	5	5	11	21	22	7	102
Cumulative number of skates used	856	339	338	248	239	360	966	994	261	4,601
No. of fish tagged										
Sockeye—*mature*	198	248	0	6	1	0	0	2	4	459
immature	114	0	1	367	284	0	0	0	11	777
Total	312	248	1	373	285	0	0	2	15	1,236
Chum —*mature*	231	118	9	24	23	36	56	235	6	738
immature	735	260	69	72	352	0	0	216	31	1,735
Total	966	378	78	96	375	36	56	451	37	2,473
Pink	182	33	12	1	1	273	857	1,158	6	2,523
Coho	2	0	35	19	3	0	0	27	35	121
Chinook	5	23	4	0	1	1	3	15	0	52
Total	1,467	682	130	489	665	310	916	1,653	93	6,405
Steelhead								1		

Note: Areas A-E by *Wakashio-maru*, and Areas F-I by *Takuyo-maru*.

are shown in Table 4. The distinction between matures and immatures was based on the length of the fish at tagging, the gonad weight at recapture (on the high seas), the date and place of tagging, etc. The figures shown here, accordingly, are subject to correction. The same type of division into mature and immature salmon was also made for the fish tagged in 1958 and 1959 and the result is shown in Tables 5 and 6. The length composition is shown, by month, for the sockeye and chum salmon tagged in Aleutian

Table 5. Tagging by *Tenyo-maru*, 1958.

Area of tagging[1]	A	B	C	Total
Period	6.5-6.19	6.25-7.24	7.29-8.18	
No. of operations	15	21	18	54
Cumulative number of skates used	557	930	865	2,352
No. of fish tagged[2]				
Sockeye—*mature*	69	263	3	335
immature	2	66	680	748
Total	71	329	683	1,083
Chum —*mature*	67	191	94	352
immature	251	363	714	1,328
Total	318	554	808	1,680
Pink	59	184	—	243
Coho	1	25	123	149
Chinook	4	6	1	11
Total	453	1,098	1,615	3,166

1) See INPFC Annual Report, 1958, for tagging areas.
2) Numbers of fish tagged by species do not coincide with those given in the previous research summary (1958). Species identification has been changed for some recoveries after examining the scales taken at the time of tagging and/or recovery. Also, in this table sockeye and chum salmon are divided into matures and immatures and the fish for which scales and measurements are not available are excluded.

TABLE 6. Tagging by *Tenyo-maru* and *Wakashio-maru*, 1959.

Area of tagging[1]	A	B	B′	C	D	E	Total
Period	5.24–6.25	6.8–6.29	7.22–7.30	7.1–7.19	7.16–7.24	7.25–8.22	
No. of operations	14	15	7	13	8	27	84
Cumulative number of skates used	621	615	350	533	398	1,260	3,777
No. of fish tagged[2]							
Sockeye—*mature*	235	393	102	67	2	25	824
immature	26	117	204	54	0	492	893
Total	261	510	306	121	2	517	1,717
Chum —*mature*	329	135	24	201	46	194	929
immature	443	484	260	338	8	638	2,171
Total	772	619	284	539	54	832	3,100
Pink	595	576	40	686	71	33	2,001
Coho	11	11	226	2	110	398	758
Chinook	2	31	29	81	—	37	180
TOTAL	1,641	1,747	885	1,429	237	1,817	7,756

1) See INPFC Annual Report, 1959, for tagging areas.

2) Numbers of fish tagged by species do not coincide with those given in the previous research summary (1959). Species identification has been changed for some recoveries after examining the scales taken at the time of tagging and/or recovery. Also, in this table sockeye and chum salmon are divided into matures and immatures and the fish for which scales and measurements are not available are excluded.

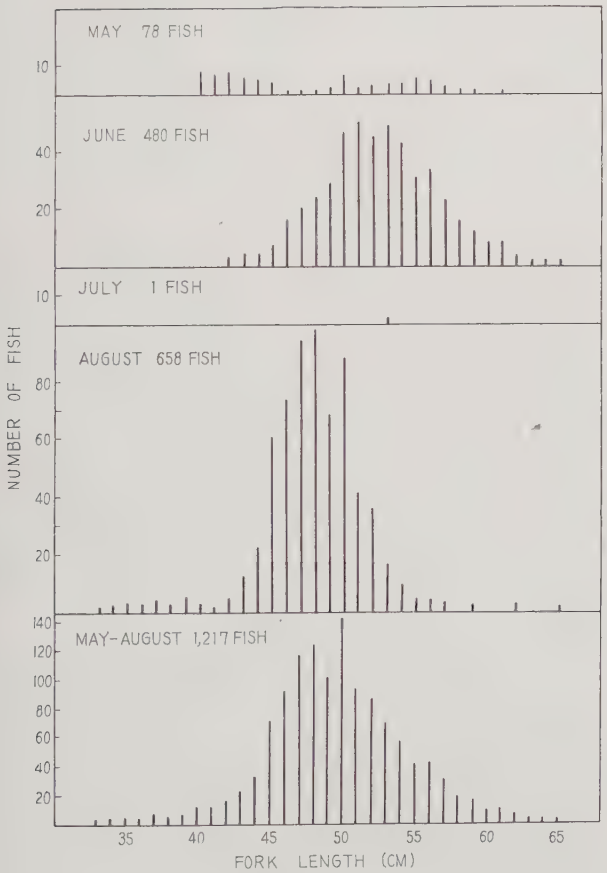

FIGURE 6. Length composition of sockeye salmon tagged (Aleutian waters).

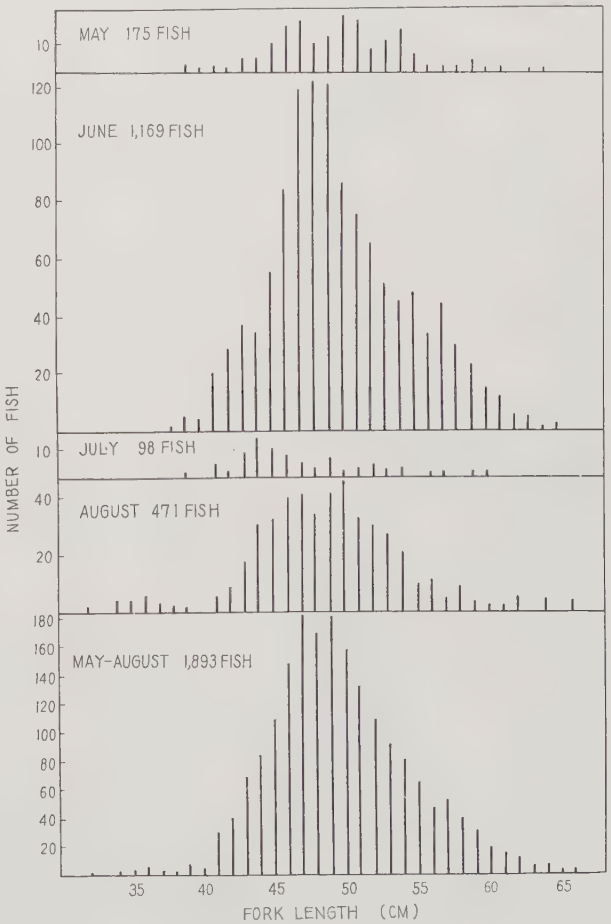

FIGURE 7. Length composition of chum salmon tagged (Aleutian waters).

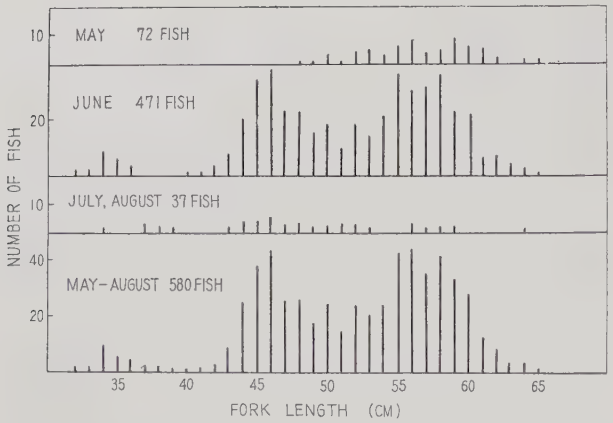

FIGURE 8. Length composition of chum salmon tagged (south of 48°N.).

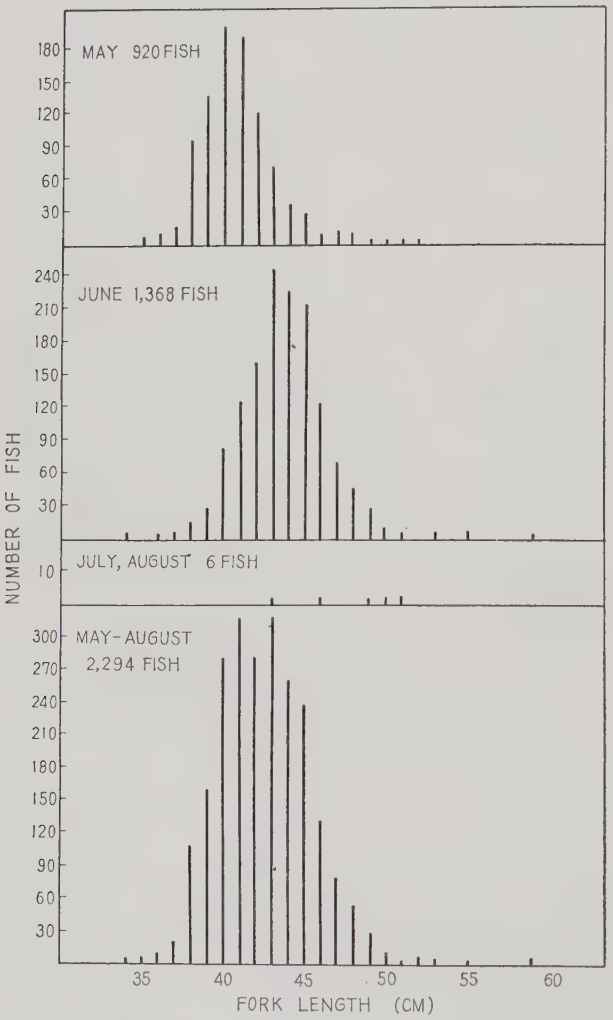

FIGURE 9. Length composition of pink salmon tagged (south of 48°N.).

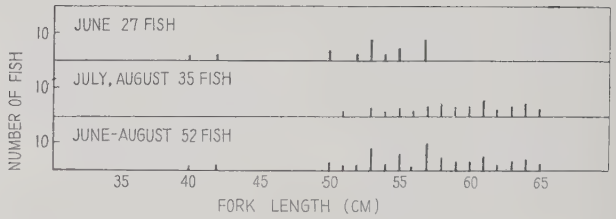

FIGURE 10. Length composition of coho salmon tagged (south of 48°N.).

waters (Figures 6 and 7) and the chum, pink and coho salmon tagged in waters south of 48° N. (Figures 8, 9 and 10).

Recoveries

The recoveries, as of January 20, 1961, from tagging in 1959 and 1960, are shown in Tables 7 and 8 and Figures 11 to 15. The recaptures of sockeye and chum salmon from tagging in 1960 indicate about the same results as those obtained from 1959 tagging. Japan did not tag many pinks in 1960 and only a few recoveries were made. The recaptures on the high seas from tagging by the United States suggest, however, that in 1960 there were considerable quantities of pink salmon bound for Olyutorski, Karaginski and some other districts of Asia, in Aleutian waters west of 180° during the month of June. This is different from the results of pink salmon tagging in 1958; in 1958 only small numbers of pink salmon were tagged in these waters and the few recoveries obtained were all from the Bering Sea coast of Alaska.

Since some additional recoveries (mostly from the U.S.S.R.) of fish tagged and recaptured in 1959 have been reported, the results of 1959 tagging are summarized in Table 7. It is noted, from these results, that some of the mature chum salmon bound for West Kamchatka and the Okhotsk district were present in central Aleutian waters, the western Bering Sea and the northwest Pacific during the summer (Figure 12-B), and that the pink salmon bound for Karaginski, West Kamchatka, the Okhotsk district and Sakhalin were intermingled in waters south of the Kamchatka Peninsula (vicinity of 160° E. and 45°–50° N.) during late June.

Some of the 1960 recaptures from 1959 tagging present new information. One sockeye tagged in an area off southeast Kamchatka in 1959 was recaptured in the central Bering Sea in 1960 as an apparently mature fish (recaptured July 2; female; gonad weight 45 g.; age 5_2); and three chum salmon tagged in waters around the Commandorski Islands in 1959 were recaptured in the northwest Pacific off the South Kurile Islands in 1960.

TABLE 7. Recoveries by areas of tagging, 1959.[1]

Area[2] of tagging	Species	Area of recovery									
		Mothership grounds		South of	Coastal waters & streams						
		North Pacific	Bering Sea	48°N	Alaska	B.C.	Hokkaido	Okhotsk	W. Kamchatka	E. Kamchatka	Total
A	Sockeye	40 (1)	1	—	—	—	—	—	—	1	42 (1)
	Chum	24	—	1	—	—	1	2	—	1	29
	Pink	5	1	8	—	—	1	3	2	1	21
	Coho	—	—	1	—	—	—	—	—	—	1
	TOTAL	69 (1)	2	10	—	—	2	5	2	3	93 (1)
B	Sockeye	—	1 (1)	—	11[3] (1)	1	—	—	—	—	13 (2)
	Chum	7	—	—	—	—	1[6]	—	2	1	11
	Pink	—	6	—	—	—	—	—	—	—	6
	TOTAL	7	7 (1)	—	11 (1)	1	1	—	2	1	30 (2)
B′	Sockeye	1	(1)	—	1[4]	—	—	—	—	—	2 (1)
	Chum	(1)	—	—	—	—	2	—	—	—	2 (1)
	Coho	—	—	—	8	—	—	—	—	2	10
	TOTAL	1 (1)	(1)	—	9	—	2	—	—	2	14 (2)
C	Sockeye	(1)	4	—	1	—	—	—	—	—	5 (1)
	Chum	(1)	9	—	—	—	8	—	4	3	24 (1)
	Pink	—	18	—	—	—	—	—	—	10	28
	Chinook	—	—	—	(1)	—	—	—	—	—	(1)
	TOTAL	(2)	31	—	1 (1)	—	8	—	4	13	57 (3)
D	Sockeye	—	—	—	—	—	—	—	1	—	1
	Chum	—	—	—	—	—	—	1	—	—	1
	Pink	—	—	2	—	—	—	—	—	—	2
	Coho	—	—	3	—	—	—	4	1	—	8
	TOTAL	—	—	5	—	—	—	5	2	—	12
E	Sockeye	(12)	(1)	(1)	—	—	—	—	—	—	(14)
	Chum	(3)	—	(4)	—	—	20[7]	1	1	4	26 (7)
	Pink	—	—	—	—	—	—	—	1	—	1
	Coho	—	—	—	—	—	—	1	7	9	17
	Chinook	—	—	(1)	—	—	—	—	—	—	(1)
	TOTAL	(15)	(1)	(6)	—	—	20	2	9	13	44 (22)
Total	Sockeye	41 (14)	6 (3)	(1)	13[5] (1)	1	—	—	1	1	63 (19)
	Chum	31 (5)	9	1 (4)	—	—	32[8]	4	7	9	93 (9)
	Pink	5	25	10	—	—	1	3	3	11	58
	Coho	—	—	4	8	—	—	5	8	11	36
	Chinook	—	—	(1)	(1)	—	—	—	—	—	(2)
	TOTAL	77 (19)	40 (3)	15 (6)	21[5] (2)	1	33[8]	12	19	32	250 (30)

1) Numbers in parentheses are recoveries during the next year.
2) See INPFC Annual Report, 1959, for areas of tagging.
3) Including one from Kodiak Island.
4) Kodiak Island.
5) Including two from Kodiak Island.
6) Sakhalin.
7) Including one from Sakhalin.
8) Including two from Sakhalin.

TABLE 8. Recoveries by areas of tagging, 1960.[1)]

Area of tagging	Species	Area of recovery					Total
		Mothership grounds		South of 48°N	Coastal waters & streams		
		North Pacific	Bering Sea		Alaska	Hokkaido	
A	Sockeye	11	1	—	2	—	14
	Chum	22	1	—	—	—	23
	Pink	1	—	—	—	—	1
	TOTAL	34	2	—	2	—	38
B	Sockeye	—	—	—	50	—	50
	Chum	—	—	—	12	1	13
	TOTAL	—	—	—	62	1	63
C	Pink	—	—	1	—	—	1
	TOTAL	—	—	1	—	—	1
E	Chum	—	—	—	—	1	1
	TOTAL	—	—	—	—	1	1
F	Chum	—	—	2	—	—	2
	Pink	—	—	3	—	—	3
	TOTAL	—	—	5	—	—	5
G	Pink	1	—	15	—	1	17
	TOTAL	1	—	15	—	1	17
I	Chum	—	—	9	—	—	9
	Pink	—	—	30	—	—	30
	TOTAL	—	—	39	—	—	39
Total	Sockeye	11(1)	1	—	52	—	64(1)
	Chum	22(2)	1	11(1)	12	2	48(3)
	Pink	2	—	49(4)	—	1	52(4)
	TOTAL	35(3)	2	60(5)	64	3	164(8)

[1)] Numbers in parentheses are recoveries for which either the area of tagging or the area of recovery is unknown.

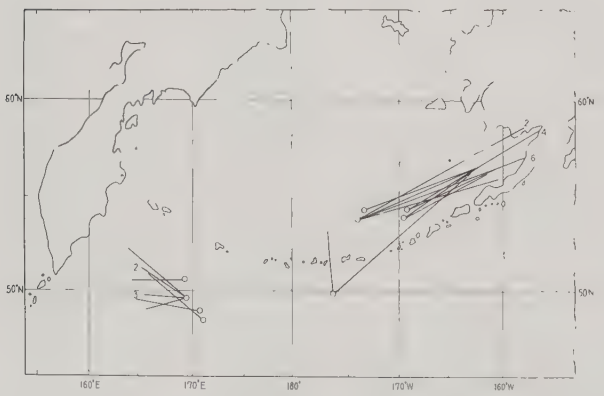

FIGURE 11-A. Recoveries of tagged sockeye salmon. Tagged in 1960—recovered in 1960.

Notes: (1) Two fish released as chum and recovered as sockeye (in Bristol Bay) are not included. (They are included in Figure 12-A.)

(2) Two fish recovered at Ilinik, Alaska Peninsula, are not included, because this place cannot be located on the map.

(3) Lines without numbers represent one recovery each.

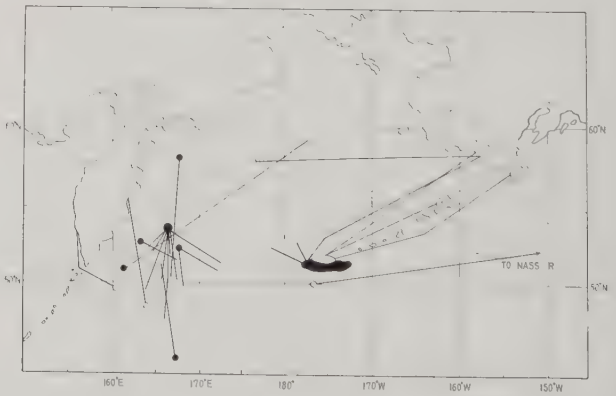

FIGURE 11-B. Recoveries of tagged sockeye salmon. ○ Tagged in 1959—recovered in 1959 (coastal recoveries only); ● Tagged in 1959—recovered in 1960.

Note: Lines without numbers represent one recovery each.

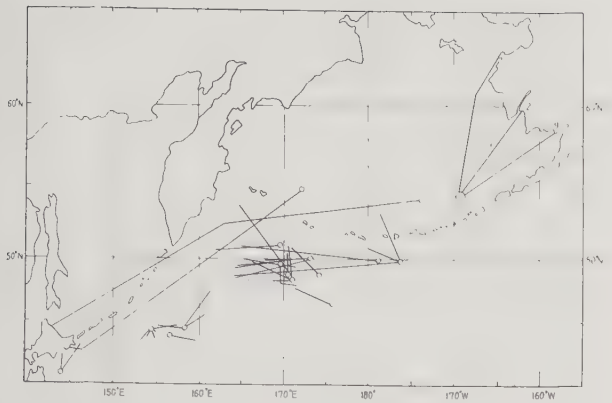

FIGURE 12-A. Recoveries of tagged chum salmon. Tagged in 1960—recovered in 1960.

Notes: (1) Not including one fish for which the place of recovery is not known and another fish for which the tag was lost.
(2) Including two fish recovered as sockeye.
(3) Lines without numbers represent one recovery each.

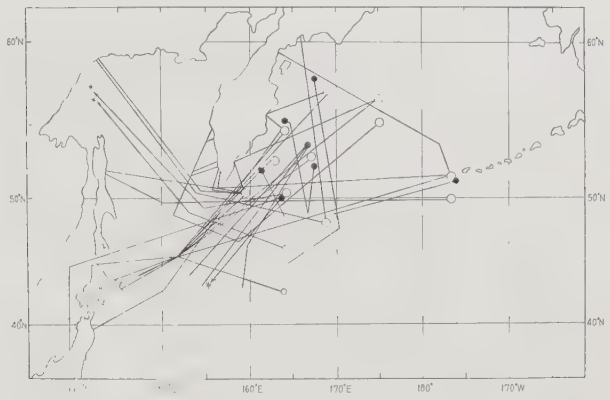

FIGURE 12-B. Recoveries of tagged chum salmon. ○ Tagged in 1959—recovered in 1959 (coastal recoveries); ● Tagged in 1959—recovered in 1960.

Note: Three fish recovered from East Kamchatka are not included, because the streams given in the recovery data cannot be located on the map. These fish were tagged in the vicinity of 55°N. × 167°E. in 1959 and recovered in the same year.

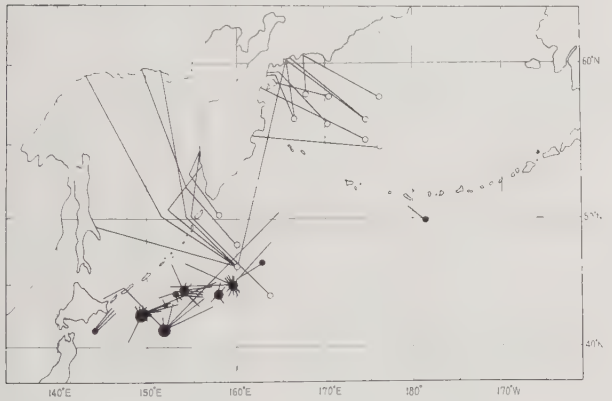

FIGURE 13. Recoveries of tagged pink salmon. ○ Tagged in 1959—recovered in 1959 (coastal recoveries); ● Tagged in 1960—recovered in 1960.

Note: Not including four fish for which recovery data are being checked (all tagged and recovered in 1960).

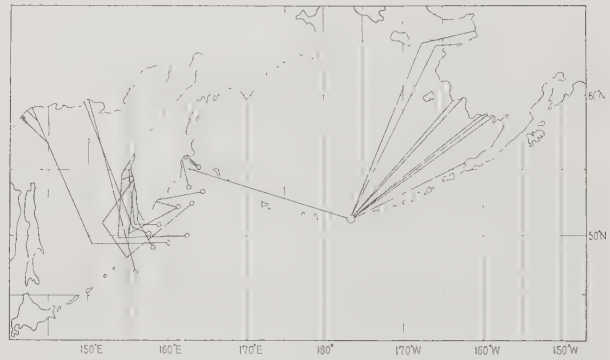

FIGURE 14. Recoveries of tagged coho salmon. Tagged in 1959—recovered in 1959 (coastal recoveries only).

Note: Four fish recovered from East Kamchatcka are not included, because for three of them the streams given cannot be located on the map and the name of the stream is not given for the fourth.

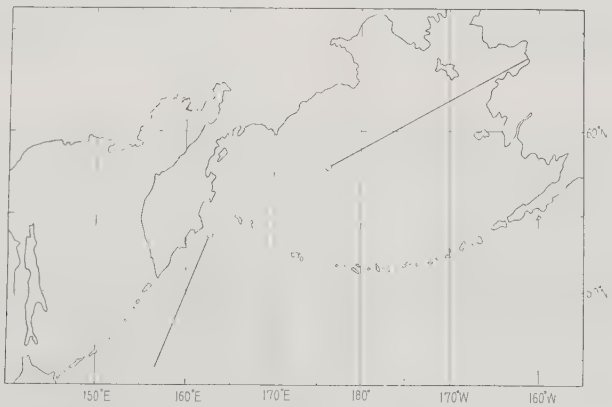

FIGURE 15. Recoveries of tagged chinook salmon. Tagged in 1959—recovered in 1960.

4. Oceanographic Investigations

In 1960, the *Oshoro-maru* of Hokkaido University and the new research vessel *Hokko-maru* of the Hokkaido Regional Fisheries Research Laboratory were engaged in oceanographic investigations. The *Oshoro-maru* stopped at Juneau and Seattle during the course of her cruise, and received a warm welcome from various members of the U.S. Fish and Wildlife Service.

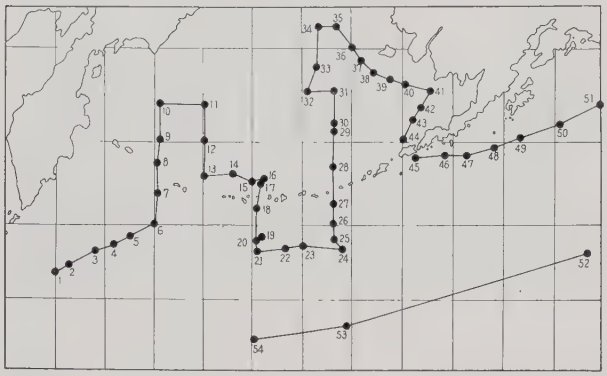

Figure 16. Stations occupied by the *Oshoro-maru*, 1960.

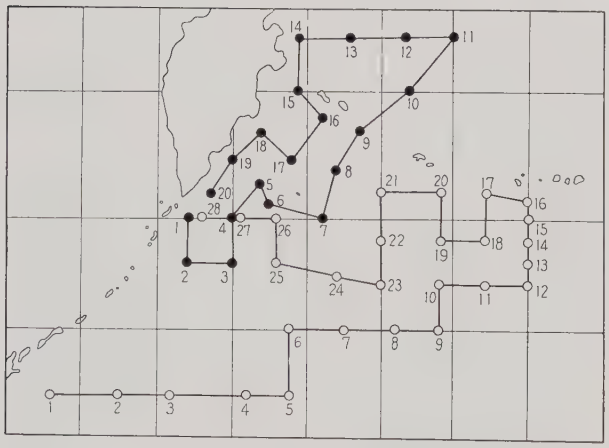

Figure 17. Stations occupied during the 1st and 2nd cruises of the *Hokko-maru*, 1960.

○ 1st cruise ● 2nd cruise

The cruise maps and stations are shown in Figures 16 and 17 for both vessels. Analysis of data has not been completed as yet, and only an outline of investigations is given below:

(1) *Oshoro-maru* (616 g.t.)

(i) Cruise period: June 6–August 27.

(ii) Area of investigation: The North Pacific north of 48° N. and the Bering Sea (Figure 16).

(iii) Items of investigation:

a. Oceanographic observations (wire length up to 1,500 m.): temperature, chlorinity, dissolved oxygen, phosphate, silicate, pH.

b. Plankton collection: vertical tows from 150 m. to the surface using the North Pacific standard net; vertical tows from 100 m. to the surface using a phytoplankton net; and 10-minute surface tows using a larval net at a low speed.

(2) *Hokko-maru* (220 g.t.)

(i) Cruise period: July 19–August 25.

(ii) Area of investigation: The northwest Pacific north of 42° N. and the Bering Sea (Figure 17).

(iii) Items of investigation:

a. Oceanographic investigations (wire length up to 1,000 m.): temperature and chlorinity.

b. Plankton collection: vertical tows from 100 m. to the surface using the North Pacific standard net; vertical tows from 100 m. to the surface using a phytoplankton net; and 10-minute surface tows using a larval net at a low speed.

II. PROGRESS REPORT ON KING CRAB RESEARCH IN THE EASTERN BERING SEA

As in past years, king crab studies in the eastern Bering Sea in 1960 were conducted by a research worker aboard the crab mothership.

1. Summary of Fishing Operations in 1960

The Japanese king crab fleet in 1960 consisted of the mothership *Tokei-maru* and three independent fishing vessels of 60–70 g.t. each. The mothership arrived at the fishing grounds on April 16. At the time of arrival a band of drifting ice was observed in waters 30 miles off Amak Island, but it drifted away westward and offshore in a few days, causing no damage. Air temperature was unusually low during the

earliest part of the season, being –7°C. Sometimes crabs were frozen when landed. The weather was fine otherwise, and only two full days and two half-days were lost because of storms. The surface water temperature gradually rose from 1.5°C. to 2.6°C. during the fishing season. Fishing was good, and the average catch per tan of tangle-net was 17.3 crabs, compared with 16.4 crabs in 1959. However, the proportions of relatively small adult crabs and crabs with fouled shells were somewhat higher, and the average number of crabs required for producing one case of canned crab was 20.1, compared with 18.5 in 1959. A total of 80,000 cases of 48 half-pound cans each, which is equivalent to a total meat weight of 1,920,000 pounds, was produced by July 6.

A Soviet crab fleet, consisting of the mothership *Vsevolod Sibirtsev* and several independent fishing vessels, arrived at the fishing grounds earlier than the Japanese fleet. Both fleets operated in the same area off Black Hill until the end of May, but there was little interference in actual fishing operations.

Mr. T. Miyahara, a research worker of the U.S. Fish and Wildlife Service, visited the *Tokei-maru* from the American fishing vessel *Deep Sea* to coordinate the research work of the two countries.

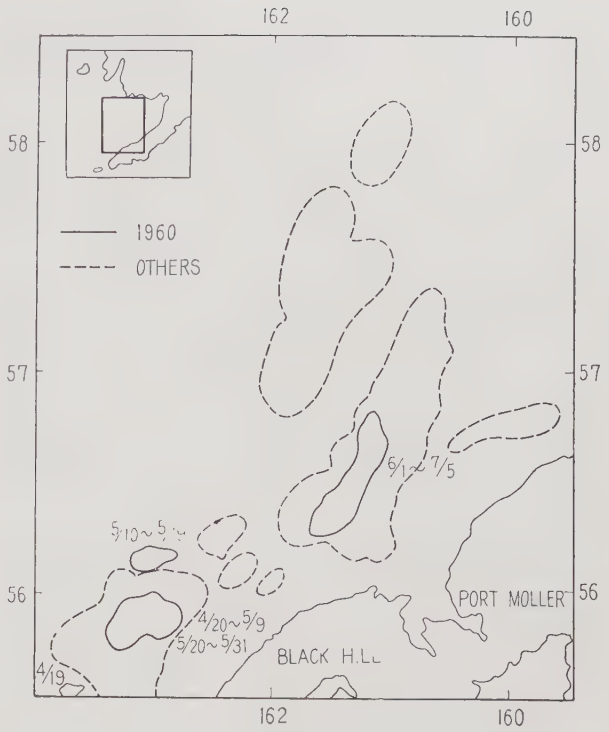

FIGURE 18. Tangle net grounds, 1960.

2. Some Detail of Operations

The fishing grounds occupied in 1960 are compared with those in previous years in Figure 18. Some new grounds were visited in waters off Amak Island and Black Hill, but the grounds off Port Moller had been fished in the past. The fishing grounds off Amak Island were covered only once, at the very beginning of the season. The average number of days nets soaked was three days and the catch per tan of tangle-net was 3.5 in this area. The average carapace length of the crabs caught in this area was larger than those on other grounds, being 161.9 mm. The fishing grounds off Black Hill were occupied during the period from April 20 to May 31, and those off Port Moller were used from June 1 to July 6, when the fleet left for Japan. Table 9 shows the catch and canned crab production by month and measurement data by fishing area. The average catch per tan was higher for the grounds off Port Moller than for the grounds off Black Hill, but the average carapace length of the crabs caught was about the same in both areas. Detailed analysis of the data is underway.

3. Tagging

Tagging in 1960 was conducted mainly for the purpose of obtaining data on the growth of king crabs. The tag consisted of a yellow celluloid plate and a yel-

TABLE 9. Catches and measurements of king crabs in the eastern Bering Sea—1960.

Period	No. of tans hauled	Aver. no. of days nets soaked	No. of crabs caught	Catch per tan	Pack in cases*	Aver. carapace length	Aver. carapace width	Aver. weight
4/19-4/30	15,778	6.5	194,030	12.3	9,759	158.4 (161.9)	186.4 (190.5)	3.0 (3.1)
5/1 -5/31	36,280	19.4	636,826	17.6	33,032			
6/1 -6/30	34,852	27.1	655,285	18.8	31,039	157.9	186.3	3.1
7/1 -7/5	6,243	21.4	124,622	20.0	6,170			
Total	93,153	20.4	1,610,763	17.3	80,000	158.2	186.4	3.0

* 24 lbs. per case.

Figures in brackets are those for crabs caught on April 19 (in waters off Amak Island).

low tube made of vinyl-acetate. The tube was put through the muscle tissue below the posterior edge of the carapace. A total of 876 crabs was tagged in two operations.

Tagging lot	*Date of tagging*	*Position of tagging*	*No. of crabs tagged*		*Total*
			Male crabs of legal size	*Under-sized male crabs*	
1	May 27	55°56′N.×162°52′W.	454	24	478
2	June 29	56°47′N.×161°10′W.	385	13	398

In both cases, tagging was done immediately before the departure of the fleet from the area, in order to prevent crabs from being caught shortly after tagging. Accordingly, there were no recaptures this year. Six crabs tagged in 1959 were recapturd during the 1960 season (Table 10).

Table 10. Tagging and recovery data for the six crabs tagged in 1959 and recaptured in 1960.

Tag no.	Type[1] of tag	Date of release	Position of release	Sex	Date of recapture	Position of recapture	Size in mm.[2]
		1959			1960		
58	Spaghetti	April 22	55°42′N×163°17′W	M	May 23	55°53′N×162°50′W	—
98	〃	〃 〃	55°43′N×163°11′W	〃	〃 〃	55°53′N×162°50′W	167×197
119	〃	〃 〃	55°46′N×163°13′W	〃	〃 24	55°53′N×162°50′W	166×195
244	〃	〃 〃	55°52′N×163°27′W	〃	〃 22	55°55′N×162°51′W	165×195
322	〃	〃 〃	55°48′N×163°29′W	〃	〃 28	55°51′N×163°00′W	176×205
436	〃	〃 23	55°56.5′N×163°18′W	〃	April 27	55°52′N×163°12′W	184×228

1) The purpose of tagging was to study the movements of crabs during the fishing season and not to study the growth of crabs; accordingly tags were affixed to the basipodite of a walking leg.

2) Carapace length×carapace width.

4. Juvenile Crabs

The collection of juvenile king crabs (2–33 mm. in carapace length) has been carried out every year since 1956, when such crabs were first found in the eastern Bering Sea. Continuous collections were made in 1960 from June 1 through the end of the season in the crab grounds off Port Moller. A total of 506 juvenile crabs was obtained (including five crabs for which measurement data are not available). The area of collection was about the same as in previous years, as shown in Figure 19. Eighty-seven per cent of the juvenile crabs collected this year were from the southern part of this general area (shaded area in Figure 19), and only a very few crabs were from waters farther offshore.

The juvenile crabs thus collected were reared for the purpose of observing the process of moulting and determining the average growth per moult. The crabs collected by net-hauling boats were kept in sea water and transferred onto the mothership, where they were put in glass jars and thermos bottles. Many juvenile crabs died before June 10 from the contamination of sea water by benthonic animals which had come in the containers with the crabs. Thereafter crabs were kept with sand and gravel, and the mortality became very low. Moulting started on June 9.

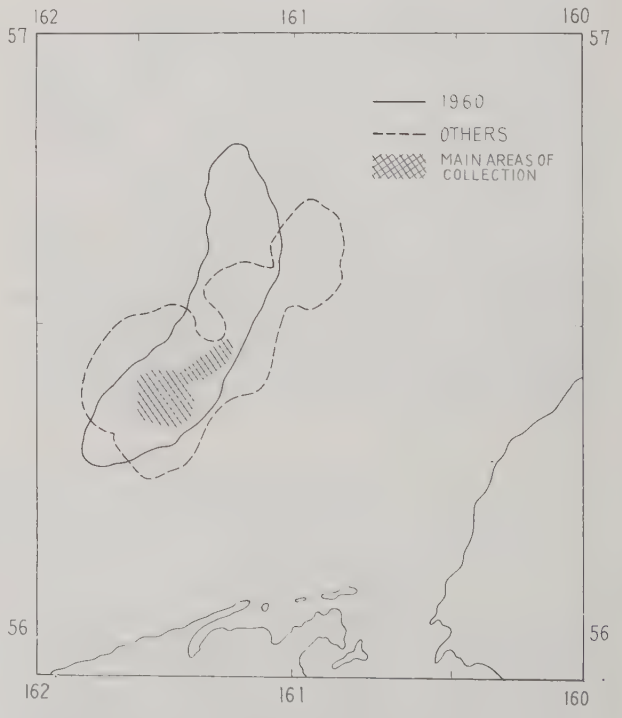

Figure 19. Areas in which juvenile crabs were collected.

Moulting began with the swelling and sagging of the abdomen, and the process proceeds quickly with

the appearance of a crack on the dorsal side of a membrane between the thorax and abdomen. It takes about 15–20 minutes for a crab to cast the old shell completely, but sometimes damage on the walking legs and other things prolonged the process. Some crabs died before the completion of the moulting process. It was observed that crabs sought food 48 hours after moulting.

A total of 33 crabs moulted, including one which moulted on the way home. A total of 31 crabs, excluding two which died in the process of moulting, was measured before and after moulting. The carapace length before moulting was 9.0–16.6 mm. (average 11.7 mm.), and the net increment per moult was 11.1–24.7 per cent (average 18.0 per cent). In carapace width, the figures were 8.2–16.2 mm. (average 10.9 mm.) and 11.8–32.1 per cent (average 18.4 per cent), respectively.

Rearing was continued until the mothership entered Hakodate, but no crabs moulted more than once. The crabs were fed with raw king crab meat, Caprellidae, *Mytilus* sp., shrimps and Polychaeta, with the quantity decreasing in this order. Cannibalism was observed when food was insufficient.

5. Zoea

The collection of zoea from the king crab grounds of the eastern Bering Sea has been conducted since 1955, with unsatisfactory results. In 1960, female king crabs carrying eyed eggs were reared, while the collection of zoea by larval nets was intensified.

(1) Rearing of Female Crabs

Several female crabs were transferred to the mothership for research purposes (catching of female crabs is illegal). A few crabs, which were expected to release zoea within a short period, were chosen for rearing. These female crabs released zoea on the day of catch or the next day, and they died soon after. The zoea thus released were reared using the nauplii of *Artemia salina* as food. All zoea, however, died before they reached the second zoea stage.

Lot No.	*Date of hatching*	*Carapace length of female crabs* (mm.)	*Carapace width* (mm.)	*Temp.of rearing tank* (°C.)	*Maximum no. of days zoea survived*	*Remarks*
1	April 26	—	—	−1.7–4.7	17	
2	May 2	125	139	2.3–4.7	8	Rearing tank was turned over by a storm and practically all zoea died.
3	May 7	120	125	2.3–4.6	5	
4	May 10	106	113	2.3–6.0	9	
5	May 13	103	109	2.3–6.0	6	
6	May 18	—	—	—	—	3 females used died before releasing zoea.
7	May 20	132	142	2.7–6.9	15	
8	May 25	111	119	2.7–6.9	12	

(2) Collection of Zoea

A vertical tow with the North Pacific standard net was carried out from the stern of the mothership at 20 stations. The samples thus collected are now being processed. Larval net tows from an independent fishing boat were conducted at four stations (see Figure 20), mainly for the purpose of studying diurnal changes in the distribution of zoea. Three methods were used: (a) surface tows for five minutes at a speed of 2 knots; (b) mid-water horizontal tows using a depressor in the layer from 30 to 50 m. for ten minutes at a speed of 2 knots; and (c) oblique tows from near the bottom to the surface at a speed (of the vessel) of 2 knots.

The numbers of zoea collected are given in Table 11. The following tentative conclusions may be drawn: (1) Zoea were distributed widely, although the concentration was different from area to area; (2) the

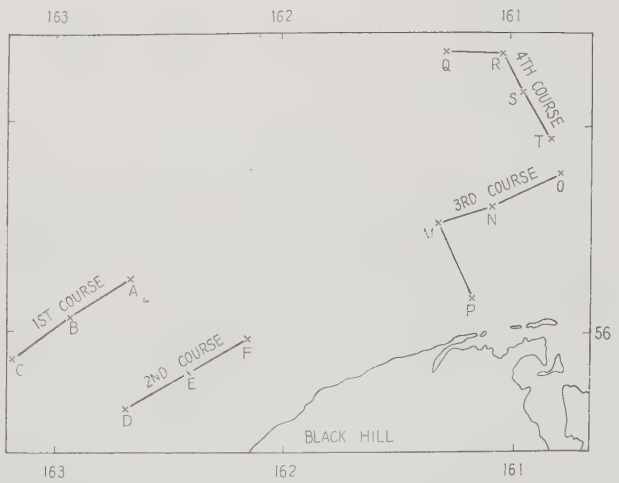

Figure 20. Stations at which larval nets were hauled.

TABLE 11. Numbers of zoea collected by larval nets.

1st Collection—(May 16–17)

Station	A		B		C	
Location	56°09′N–162°40′W		56°03′N–162°57′W		55°58′N–163°12′W	
Depth in m.	84		82		88	
Time	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset
Surface tow, 5 min.	0	4	8	9	9	6
Midwater tow, 10 min.	88	63	39	40	11	16
Oblique tow	173	142	54	64	13	4
Total	261	209	91	113	33	26

2nd Collection—(May 23–24)

Station	D		E		F	
Location	55°50′N–162°42.5′W		55°55′N–162°26′W		56°00′N–162°10′W	
Depth in m.	85		74		67	
Time	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset
Surface tow, 5 min.	10	19	1	60	2	185
Midwater tow, 10 min.	48	105	34	220	140	540
Oblique tow	38	64	32	162	151	81
Total	96	188	67	442	293	806

3rd Collection—(June 10–11)

Station	M		N		O		P	
Location	56°16′N–161°28′W		56°18′N–161°05′W		56°23′N–160°48′W		56°05′N–161°11′W	
Depth in m.	45		48		54		35	
Time	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset
Surface tow, 5 min.	0	64	465	305	81	136	636	—
Midwater tow, 10 min.	599	4,816	1,543	1,377	1,665	3,812	—	—
Oblique tow	593	1,540	2,727	465	426	2,728	18	—
Total	1,192	6,420	4,735	2,147	2,172	6,676	654	—

4th Collection—(June 29)

Station	R		S		T		Q	
Location	56°41′N–161°02′W		56°35′N–160°38′W		56°28′N–160°50′W		56°41.3′N–161°26′W	
Depth in m.	69		69		75		80	
Time	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset	Day-time	After sunset
Surface tow, 5 min.	0	—	0	—	1	—	0	—
Oblique tow	2	—	2	—	4	—	—	—
Total	2	—	2	—	5	—	0	—

highest concentration within the waters investigated was observed in an area off Port Moller on June 10–11; and (3) in general, more zoea were collected at night than during the daytime.

The zoea of tanner crab, *Erimacrus* and other species of Anomura were collected together with king crab zoea.

6. Benthonic Organisms

Benthos was collected by dredge hauls (D-type Niino dredge) from an independent fishing vessel at the same stations as the zoea collection. Also, the organisms fouling the outer surface of the king crabs landed on the mothership were sampled. Some benthos samples were collected from the tangle-nets hauled by the net-lifting boats. These samples of benthos are now being classified by experts.

TABLE 12. Canned crab production.

Year	No. of days operated	No. of motherships	No. of scouting boats	No. of deck-loaded boats	No. of tans hauled	No. of crabs caught	Catch per tan	No. of cases packed	No. of crabs per case
1953	119	1 (4,998 g.t.)	6	6	106,438 2,534	1,276,360	8.9	58,240	21.9
1954	85	1	6	6	60,516 2,095	1,060,814	11.9	59,850	17.7
1955	126	1	2	6	99,157	1,129,163	11.4	59,850	18.9
1956	103	1 (5,385 g.t.)	2	8	147,073	1,079,106	7.3	59,850	18.0
1957	70	1	3	8	83,532	1,170,951	14.0	59,850	19.5
1958	72	1	2	8	98,675	1,129,653	11.4	59,850	18.9
1959	73	1	2	8	78,364	1,291,618	16.5	70,000	18.5
1960	81	1	3	8	93,153	1,610,763	17.3	80,000	20.1

C. REPORT ON THE INVESTIGATIONS BY THE UNITED STATES FOR THE INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION—1960

These reports summarize the research work conducted during 1960. The information may be divided into two broad categories. The first is field work and the second is analysis. The field work proceeded at approximately the same level as in the past several years, and was planned to secure data regarding the distribution, origin, migrations, and abundance of salmon in the high seas. The following material describes the degree to which this was done. The analysis of the resulting data is also reported in terms of progress to the end of 1960. Detail has been omitted because of the intentionally brief nature of this annual report.

We wish to thank the scientists and agencies of Canada and Japan who have kindly furnished us with helpful advice and material.

The work which is described was done by the Seattle Biological Laboratory of the U. S. Bureau of Commercial Fisheries, with the exception of the tagging studies, which were conducted by the Fisheries Research Institute of the University of Washington.

DISTRIBUTION AND RACIAL SAMPLING OF SALMON ON THE HIGH SEAS

By M. G. Hanavan

Introduction

Salmon distribution studies conducted by the U.S. Bureau of Commercial Fisheries required the services of two chartered vessels during the 1960 season. The schooner *Pioneer* was engaged in salmon research from early May through August, and the vessel *Paragon* from early May through July.

Cruise Plans and Operations

The cruise pattern adopted for the 1960 season aimed at four major undertakings: (1) a series of stations south to 45° N. in the central Aleutian area, primarily to increase our information concerning the spring distribution of even-year pink salmon; (2) early-season stations on 170° E. to obtain samples of maturing red salmon; (3) a series of stations by both vessels through Bering Sea in June, to define the distribution and measure the relative abundance of maturing Bristol Bay red salmon; and (4) detailed sampling and environmental observations in the area south of the Aleutians where immature salmon are found in abundance during the summer period. Figure 1 shows positions of the fishing stations.

Thirty-six shackles of net (1800 fathoms), adopted as a standard set in 1959, remained the standard in 1960. Each string of gear consisted of 24 shackles of $4\frac{1}{2}$, 4 shackles of $5\frac{1}{4}$, 4 shackles of $3\frac{1}{4}$, and 4 shackles of $2\frac{1}{2}$ inch mesh.

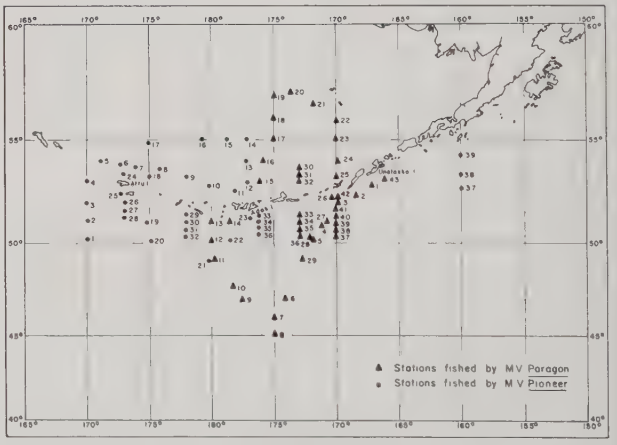

FIGURE 1. Chart showing fishing stations of the vessels *Pioneer* and *Paragon* in 1960.

Catch Statistics

The total catch of salmon during the 1960 season was 16,518 taken in 82 sets. This compares with 21,498 salmon in 76 sets in 1959. Species composition of the catch was 8,599 reds, 6,491 chums, 1,089 pinks, 285 silvers, 54 kings, and 57 steelhead. Tables

1 and 2 list the catches by individual sets showing date, location and surface temperature.

Biological analysis of the catch has not been completed; however, certain gross features show marked contrast with the catch in 1959. Although the total catch of red salmon increased, from 6,966 to 8,599, one-ocean-winter juveniles declined sharply from the very high level of abundance found in 1959. These are the reds that matured in 1960 to comprise, as 4_2 and 5_3, the bulk of the large Bristol Bay runs. The abundant one-ocean-winter juveniles of 1959 also

TABLE 1. Salmon catch by United States research vessel MV *Paragon*, May 18 through July 25, 1960.

Set no.	Haul date	Set position Lat. N.	Long.	Temp. C.	Red	Chum	Pink	Silver	King	Total	Steelhead
1	5/18	52°50′	167°00′W	5.4	6	16	2		1	25	
2	5/19	52°25′	168°31′W	5.8	1	44	2			47	
3	5/22	52°00′	169°59′W	4.5	5	45				50	
4	5/23	51°04′	170°49′W	5.2	235	63	23			321	
5	5/24	50°06′	171°40′W	4.4	94	22	20			136	
6	5/27	47°03′	174°10′W	4.6	4	86	41			131	
7	5/28	46°00′	174°59′W	5.4	14	16	21			51	
8	5/29	45°00′	175°00′W	6.5	60	4	6	2		72	4
9	5/31	47°00′	177°11′W	5.3	4	73	21			98	
[1]10	6/ 1	47°44′	177°46′W	5.1	15	43	9			67	
11	6/ 4	49°01′	180°00′	4.4	6	67	8			81	
12	6/ 5	50°02′	179°59′E	4.6	51	94	9			154	
13	6/ 6	51°00′	179°59′E	5.3	351	182	27			560	
14	6/ 7	51°04′	178°30′W	5.4	174	26	5			205	
15	6/15	53°00′	176°10′W	5.1	278	15	35			328	
16	6/16	54°01′	175°38′W	5.5	282	20	9		6	317	
*17	6/17	55°00′	175°01′W	5.8	8	9	14		6	37	
18	6/18	56°01′	175°00′W	5.8	67	18	15		2	102	
19	6/19	57°01′	174°59′W	5.7	71	65	81		9	226	
20	6/20	56°42′	173°27′W	5.7	280	71	12		4	367	
*21	6/21	56°21′	171°41′W	5.8	170	58	2			230	
*22	6/22	55°58′	169°59′W	6.2	259	13			1	273	
*23	6/23	55°00′	170°01′W	6.4	101	11	2			114	
24	6/24	54°00′	169°59′W	6.2	196	198	14		1	409	
25	6/25	53°20′	169°59′W	6.2	195	94	5			294	
26	6/26	52°15′	169°57′W	6.8	98	165	12			275	
27	6/27	51°18′	170°37′W	6.6	84	59	2			145	
28	6/28	50°07′	171°43′W	7.0	101	89	9			199	
29	6/29	49°05′	172°31′W	6.7	19	104	1			124	
30	7/ 7	53°44′	173°00′W	7.7	59	42	3		6	110	
31	7/ 8	53°26′	173°01′W	7.6	26	20	1		2	49	
32	7/ 9	53°06′	173°01′W	7.4	2	2				4	
33	7/11	51°29′	173°04′W	8.9	183	17	3	12	1	216	1
34	7/12	51°09′	173°01′W	8.9	114	11	3	2		130	2
35	7/13	50°50′	172°59′W	8.6	72	51	11	5		139	3
36	7/15	50°29′	173°00′W	8.6	33	57	18	21	1	130	12
37	7/17	50°29′	170°00′W	11.0	70	53	25	12		160	
38	7/18	50°54′	170°02′W	10.9	232	119	30	21	1	403	
39	7/19	51°13′	170°02′W	10.8	132	63	23	9		227	2
40	7/20	51°32′	170°01′W	11.1	138	72	15	11		236	1
41	7/21	51°51′	169°59′W	11.0	306	609	78	10		1,003	2
42	7/23	52°15′	170°00′W	11.0	89	541	63	8		701	1
43	7/25	53°05′	166°05′W	9.6	43	1,215	76	5		1,339	
			Total		4,728	4,642	756	118	41	10,285	28

* 24 shackles fished.

[1] Haul position.

TABLE 2. Salmon catch by United States research vessel MV *Pioneer*, May 28 through August 26, 1960.

Set no.	Haul date	Set position Lat. N.	Long.	Temp. C.	Red	Chum	Pink	Silver	King	Total	Steel-head
1	5/28	50°07′	170°04′E	3.9	61	21	1			83	
2	5/29	51°00′	170°00′E	4.3	12	14	31			57	
3	5/30	52°00′	170°00′E	5.2	36	96	25			157	
4	5/31	53°02′	170°00′E	4.9	31	21	6			58	
5	6/ 5	54°03′	171°04′E	4.0	11	47	10		1	69	
6	6/ 6	53°58′	172°46′E	4.8	11	14	5		1	31	
7	6/ 7	53°48′	174°13′E	4.6	8	4	11			23	
8	6/ 8	53°37′	175°54′E	4.8	41	70	37			148	
9	6/ 9	53°14′	178°08′E	4.9	6	18	15		1	40	
10	6/10	52°52′	179°51′W	5.2	8	9	4			21	
11	6/11	52°24′	178°00′W	6.0	28	18				46	
12	6/18	53°00′	176°58′W	5.6	124	12	11			147	
13	6/19	54°03′	177°05′W	5.4	204	30	1			235	
14	6/20	55°01′	176°58′W	5.4	136	37	2			175	
15	6/21	55°00′	178°52′W	6.7	25	89	65		1	180	
16	6/23	54°57′	179°23′E	5.9	43	5	5			53	
17	6/25	54°59′	175°57′E	6.1	10	30	36		1	77	
18	6/27	53°00′	175°00′E	6.1	13	226	19			258	
19	6/29	50°59′	174°55′E	7.2	91	58	5			154	
20	6/30	50°01′	175°03′E	6.6	108	15	5	2		130	
21	7/ 2	49°01′	179°56′W	6.7	22	22		1	1	46	
22	7/ 3	50°02′	178°36′W	7.0	54	31	2	3		90	
23	7/ 4	51°20′	176°45′W	7.5	95	65	3	1	1	165	
24	7/14	53°18′	173°12′E	7.7	30	50				80	
25	7/16	52°22′	172°50′E	8.5	217	95	2	1		315	
26	7/17	52°00′	173°00′E	8.4	95	77	2			174	
27	7/18	51°39′	173°02′E	8.5	139	112	2	7		260	
28	7/19	51°20′	173°00′E	8.7	73	14		4		91	1
29	7/27	51°20′	178°00′E	7.1	152	74	13	6		245	
30	7/28	51°00′	178°00′E	8.6	338	27	4	13		382	
31	7/29	50°39′	178°02′E	9.1	244	33	1	47	5	330	5
[1]32	8/ 1	50°20′	178°00′E	9.1	225	31	1	55		312	
33	8/14	51°28′	176°30′W	9.3	418	85	4	5	1	513	
34	8/17	51°00′	176°30′W	9.8	262	93		10		370	2
35	8/18	50°40′	176°30′W	10.1	253	33		7		353	10
[2]36	8/20	50°20′	176°30′W	10.1	235	36	1	1		273	3
37	8/24	52°43′	159°58′W	11.6	2	39		1		42	2
38	8/25	53°15′	160°00′W	11.9	6	27	1	1		35	3
[3]39	8/26	54°17′	160°00′W	10.9	4	6	3	2		15	3
			Total		3,871	1,849	333	167	13	6,233	29
			Pioneer		3,871	1,849	333	167	13	6,233	29
			Paragon		4,728	4,642	756	118	41	10,285	28
			Total		8,599	6,491	1,089	285	54	16,518	57

[1] Nets in water 60 hours, due to rough seas.
[2] Nets in water 36 hours, due to rough seas.
[3] Nets in water 19 hours, due to rough seas.

produced a substantial increase in two-ocean-winter immatures in 1960. These fish should comprise the major age group in the 1961 Bristol Bay runs.

Total chum catch remained the same in 1959 and 1960: 6,492 and 6,491. Size composition of the catch was not consistent, however, as 2-year fish were less abundant in the 1960 catch.

A pink salmon catch of 1,089, while far below the 7,634 taken in 1959, was substantially greater than previous even-year catches in the Aleutian area. The

increase, compared to 1956 and 1958, is attributed in part to a greater number of stations closer to the Aleutian Islands and to the local island runs.

Our 1960 catch shows little change in the abundance of the species which are of minor importance in the Aleutian-Bering Sea area; the silver catch, 285, was similar to the catch of 317 in 1959; 54 kings this year compare with 89 in 1959; and the catch of 57 steelhead in 1960 is remarkably close to the catch of 62 in 1959.

Distribution and Relative Abundance

Details of the 1960 distribution of the three major species are shown in Figures 2 to 7, which describe the distribution and relative abundance of salmon large enough to be captured in the $4\frac{1}{2}$ and $5\frac{1}{4}$ inch nets. These include pink salmon; 2, 3, and 4 ocean-winter reds; and 4, 5, and 6 year chums. Catches are shown in two panels: May-June and July-August. Relative abundance is shown as follows: (1) small open circles indicate no catch; (2) small closed circles indicate a catch of fewer than 5 fish per 100 fathoms of net; (3) intermediate closed circles indicate a catch of from 5 to 10 fish per 100 fathoms; and (4) large closed circles, a catch of more than 10 per 100 fathoms.

Figure 2 shows the distribution and relative abundance of maturing red salmon in the Bering Sea and the Aleutians westward to 170° E. Large catches were numerous and were taken over an area extending north and east in central and eastern Bering Sea and

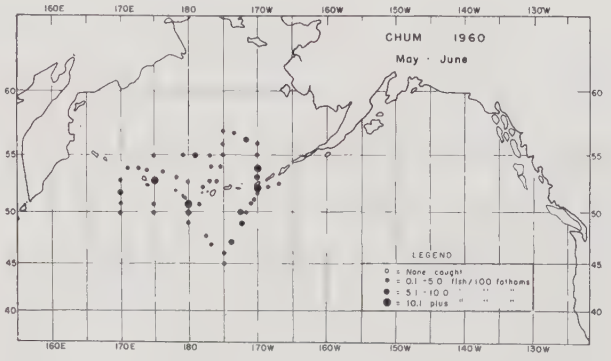

Figure 4. Chum salmon abundance, May and June 1960—4, 5, 6 year old fish taken in $4^1/_2$ and $5^1/_4$ inch mesh nets.

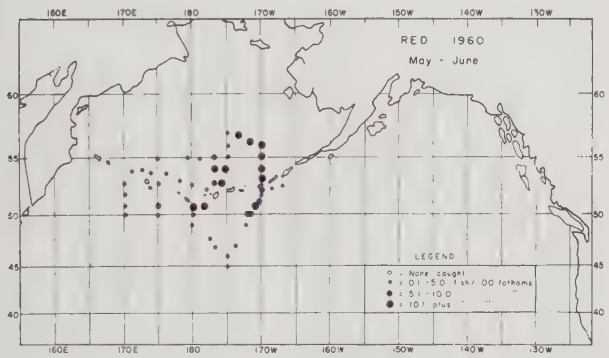

Figure 2. Red salmon abundance, May and June 1960—2, 3, 4 year ocean-age taken in $4^1/_2$ and $5^1/_4$ inch mesh nets.

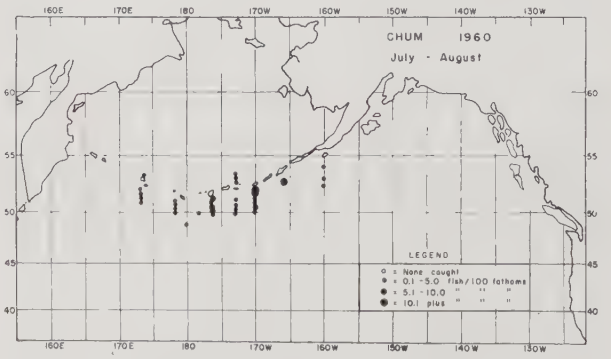

Figure 5. Chum salmon abundance, July and August 1960—4, 5, 6 year old fish taken in $4^1/_2$ and $5^1/_4$ inch mesh nets.

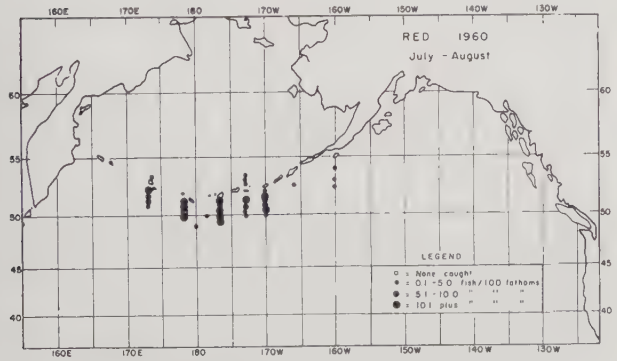

Figure 3. Red salmon abundance, July and August 1960—2, 3, 4 year ocean-age taken in $4^1/_2$ and $5^1/_4$ inch mesh nets.

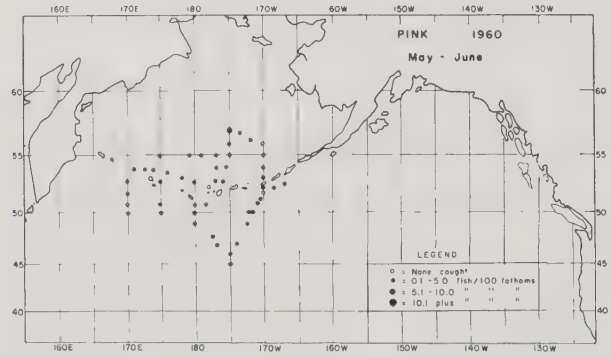

Figure 6. Pink salmon abundance, May and June 1960.

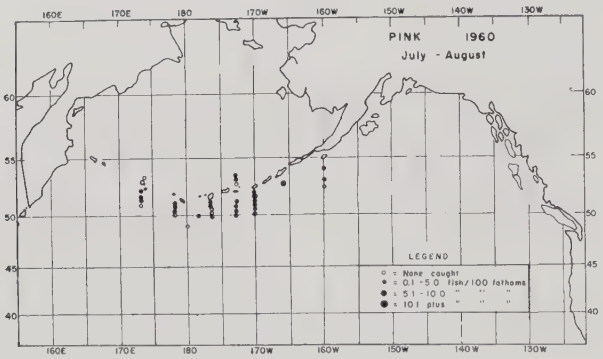

FIGURE 7. Pink salmon abundance, July and August 1960.

south of the Aleutians, indicating a high level of abundance of maturing red salmon distributed in a broad area.

A large catch of red salmon south of the Aleutian Islands in late May was composed entirely of maturing salmon, while a smaller catch taken a few days later and much farther south at 45° N., 175° W., was composed entirely of immatures. Replacement of maturing fish by immatures in the Aleutian area is a consistent feature of the summer season.

Summer fishing (Fig. 3) was limited, for the most part, to the area south of the Aleutians. The large catches recorded in this area consisted principally of the two-ocean-winter immature red salmon.

Figure 4 shows the spring distribution of chum salmon of older and larger fish. While widely dispersed, there is evidence of greatest concentrations occurring near the Aleutians. Maximum catches were recorded in late July, south of the Aleutian Islands, on 170° W. and 166° W. (Fig. 5). As shown in Table 1, these were the largest catches of any species taken during the 1960 season.

Pink salmon were taken at virtually all stations

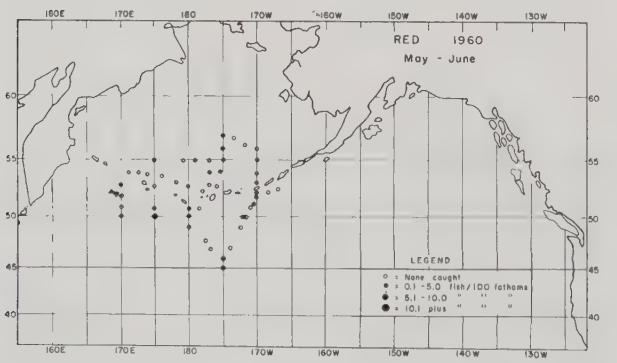

FIGURE 8. Juvenile red salmon abundance, May and June 1960—1 year ocean-age taken in $2^1/_2$ and $3^1/_4$ inch mesh nets.

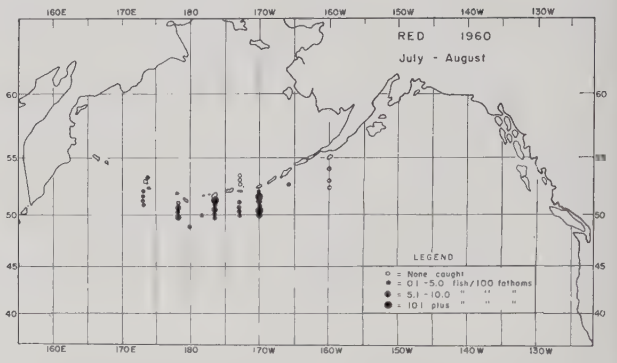

FIGURE 9. Juvenile red salmon abundance, July and August 1960—1 year ocean-age taken in $2^1/_2$ and $3^1/_4$ inch mesh nets.

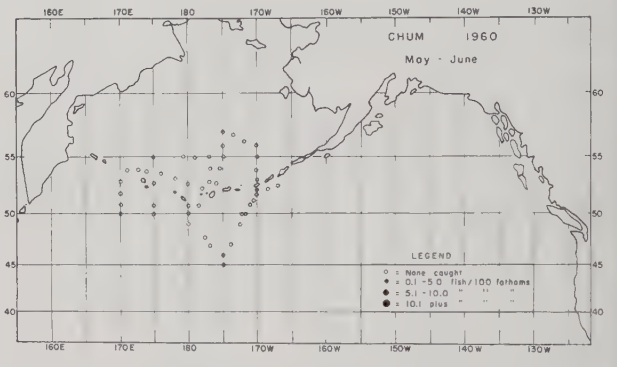

FIGURE 10. Juvenile chum salmon abundance, May and June 1960—2 year old fish taken in $2^1/_2$ inch mesh nets.

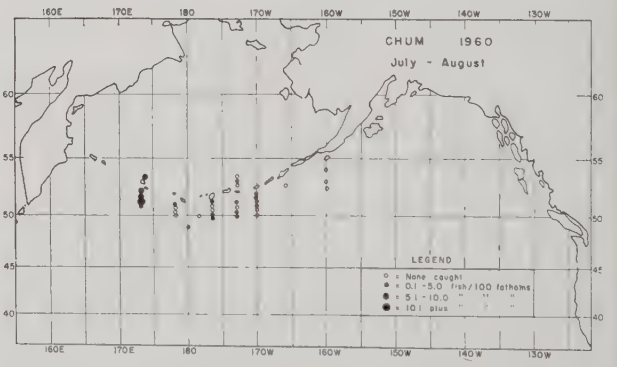

FIGURE 11. Juvenile chum salmon abundance, July and August 1960—2 year old fish taken in $2^1/_2$ inch mesh nets.

during the spring period (Fig. 6), but in the small numbers which we associate with even-year pink salmon abundance. The largest catches were recorded in late July near the Islands (Fig. 7).

Distribution of silver and king salmon and steelhead trout was consistent with previous years. Virtually all of the silvers and all of the steelhead were taken late in the season, while kings were taken oc-

casionally throughout the season, both in the Bering Sea and south of the Aleutians.

Juvenile, one-ocean-winter red salmon were scattered and few in number during the spring (Fig. 8), but appeared in greater numbers south of the Aleutians during the summer (Fig. 9).

Juvenile, 2-year-old chum salmon were completely absent during the spring (Fig. 10) and were taken in appreciable numbers only in the Attu Island area during the summer (Fig. 11).

OCEANOGRAPHY

By Felix Favorite and James F. Hebard

Introduction

The oceanographic program is limited to obtaining observations from aboard the chartered fishing vessels. Studies of specific relationships between oceanographic conditions and salmon distribution are limited to the type and amount of oceanographic work that can be accomplished. Although representing environmental conditions at fishing locations, these data are not synoptic and do not permit the gross presentation of oceanographic conditions that is obtained from independent oceanographic cruises. They do serve, however, the extremely important function of providing continuity of observations between the extensive Japanese oceanographic cruises in the western Pacific Ocean and similar Canadian cruises in the eastern Pacific Ocean. Such an integrated picture of oceanographic features across the North Pacific Ocean is required to identify salmon water and provide information concerning oceanic migration routes of the salmons.

Field Season 1960

Hydrographic Program

Routine oceanographic observations similar to those obtained in previous years were obtained, and station

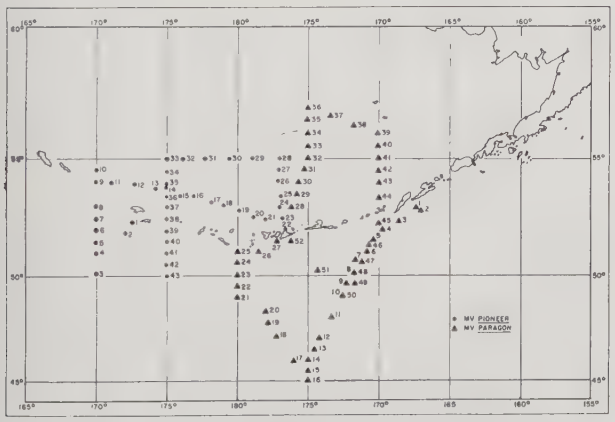

Figure 12. Oceanographic stations, May-June 1960.

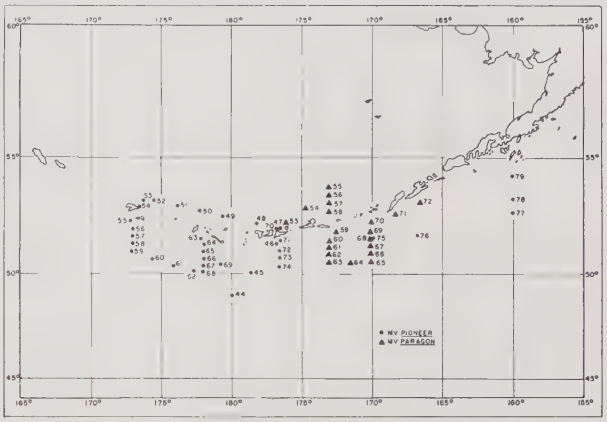

Figure 13. Oceanographic stations, July-August 1960.

positions are shown in Figure 12 for May-June cruises, during which hydrographic casts were made to 550 meters, and in Figure 13 for July and August cruises, during which casts were made to 550 and 1050 meters.

Plankton Program

During the 1960 field season, plankton samples were obtained at fishing stations using a standard $\frac{1}{2}$ meter net for vertical hauls from 300, 150 and 30 meters to the surface, and a modified Isaacs-Kidd mid-water trawl for 15 minute surface tows. Additional tows at various depths were made at selected stations to show the vertical distribution of plankton caught in the trawl, the amount and type of plankton found in specific areas or at depths of unique oceanographic features; and duplicate tows were made to check trawl reliability.

Hydrographic Investigations

Subarctic, Transition and Pacific Central Regions

In the Annual Report for 1959, a schematic diagram of Subarctic Water structure south of the Aleutian Islands was presented, utilizing 1958 data from our chartered research vessels. The extensive oceanographic cruises conducted by other agencies in 1958

have permitted a more complete investigation of these oceanographic features.

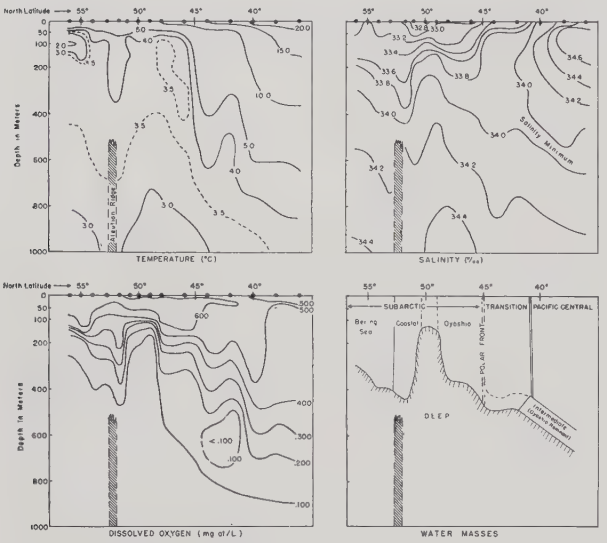

FIGURE 14. Vertical sections of temperature, salinity, dissolved oxygen and a schematic diagram of water masses along 175° East longitude, summer 1958.

Figure 14, constructed from data collected by the *Soyo-maru* (Tokai Regional Fisheries Laboratory) and our research vessels, shows vertical sections of temperature, salinity, and dissolved oxygen, and a schematic diagram of water masses identified by the structure of these constituents at 175° East longitude in summer, 1958.

The extent of the upper layer or depth to which seasonal effects are noticeable is denoted by the boundary of the Deep Water, which generally follows the 34 parts per thousand (‰) isohaline and, south of 41° North latitude, extends below the salinity minimum which denotes Intermediate Water. Physical and chemical interrelationships are quite similar in the Deep Water and, although the boundary is only approximate because of mixing processes, this water is easily identified.

Above the Deep Water, three major regions are present: Pacific Central, Transition and Subarctic. Summer heating and wind-driven currents complicate the surface conditions in these regions, but at depth, the boundaries are clearly defined. The northern boundary of Pacific Central Water occurred at about 41° North latitude and is indicated by the vertical 34‰ isohaline. The warm lens of saline water resulting from an excess of evaporation over precipitation is clearly evident to the southward.

Transition Water was present between 41° and 45° North latitude and reflects a mixing zone between Subarctic and Pacific Central Regions.

Subarctic Water occurred northward of 45° North latitude and the downward slope of the 4° and 5°C. isotherms, as well as a similar sloping of the dissolved oxygen isolines, show the sharpness of this boundary, indicated as the Polar Front, which separates Subarctic Water from the Transition Water. The Coastal, Oyashio and Bering Sea water masses shown within the Subarctic Region have been discussed in previous annual reports, and fluctuations in the extent of these water masses will be shown later in this report.

The latitudinal boundaries of the three major regions have been relatively constant during the period of INPFC investigations and the geographical extent of these regions is shown in Figure 15. The northern boundary of the Pacific Central Region, as shown by the salinity distribution, occurs at approximately 41° North latitude. This is also the southernmost extent of reported oceanic salmon catches in the central North Pacific. The southern boundary of the Subarctic Region, as indicated by the temperature distribution, coincides with the southern extent of salmon catches in summer. The Transition Region occurs between the two boundaries. It is interesting to note that in the western Pacific, at 155° East longitude, the Subarctic and Pacific Central boundaries coincide.

At this time one can only speculate on the effects of these water masses on the salmon. Possibly the Transition Water is a preferable environment for salmon during the winter, and during northward migrations in spring the cold temperatures at 50 to 100 meters may cause them to remain nearer the surface and make them more susceptible to capture in gill nets.

Subarctic Region

Although the latitudinal boundaries of the Pacific Central and Subarctic Regions have been relatively constant during the period of our investigations within the Subarctic Region, the eastern extent of Oyashio Water and the temperatures in the Coastal Water have changed considerably.

Similarity in temperature-salinity (T-S) relationships near the surface does not permit identification of water masses. However, within a salinity range of 32.9 to 34.5‰, three distinct types of T-S curves were revealed, and individual station values were enclosed in envelopes as shown in Figure 16. The 1959 data do not extend far enough southward to identify Transition Water and it will be referred to as

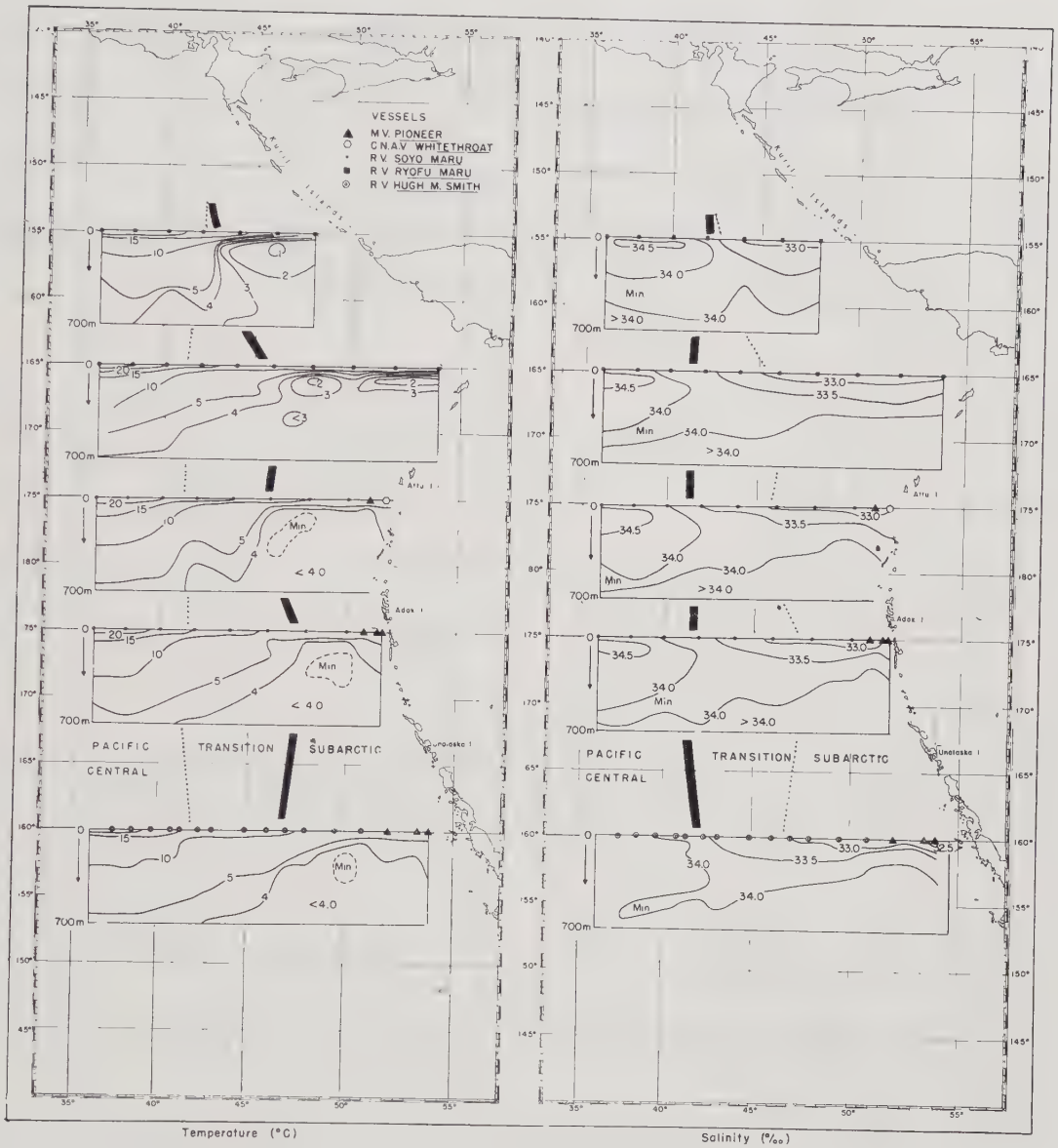

FIGURE 15. Vertical sections of temperature and salinity along 160°W., 175°W., 175°E., 165°E., and 155°E. longitudes, summer 1958. The black bar between the temperature profiles denotes the southern boundary of Subarctic Water and a similar bar between the salinity profiles denotes the northern boundary of Pacific Central Water. (Contour interval for temperature profiles: 0° to 5° C., contour interval 1° C.; 5°C. to 25°C., contour interval 5°C.)

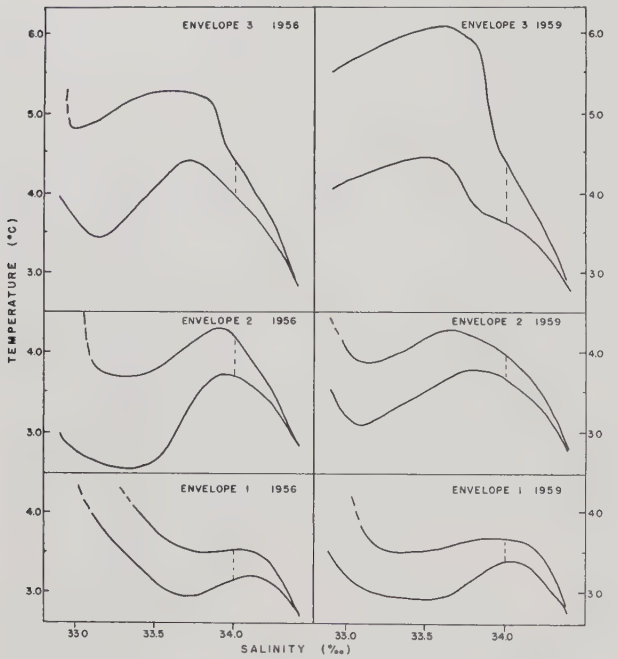

FIGURE 16. Identification of temperature-salinity relationships in Coastal (envelope 3), Mid-Gulf (envelope 2) and Oyashio (envelope 1) Water Masses for 1956 and 1959.

Southern Water. Coastal Water (envelope 3), Oyashio Water (envelope 1) and the upwelling zone between these two water masses generally referred to as Mid-Gulf Water (envelope 2) are shown. Formation of these water masses was discussed in the last annual report. The portion of the envelopes to the right of the 34.0 ‰ salinity value reflect the uniform relationships in the Deep Water.

The envelopes for 1956 and 1959 are quite similar, considering the limitations in this method of identification, which is dependent on the absence of lateral mixing of different water masses in the individual water columns. Envelopes 1 for 1956 and 1959 are nearly identical; envelope 2 shows some warming in the region of the temperature minimum in 1959; and envelope 3 shows evidence of considerable warming at higher salinities, and thus a greater depth, in 1959.

The locations of the stations utilized to define the envelopes and the geographical extent of the water masses identified are shown in Figure 17. Stations where lateral mixing of water masses occurred are isolated. It is immediately apparent that water characteristic of envelope 1 has moved from 168° West longitude in 1956 to eastward of 145° West longitude in 1959 and has considerably reduced the southern extent of the area encompassing envelope 2 in the Gulf of Alaska. The northern extent of this Mid-Gulf Water has also been reduced by an intrusion of Coastal Water (envelope 3) which is a mixture of Southern Water and water from the North American coast.

These changes are reflected by the horizontal temperature distributions at 200 meters for 1956 and 1959 shown in Figure 18. The eastward intrusion of 3.6°C. water from 168° West longitude to 148° West longitude and the westward advance of the 5°C. isotherm along the Alaska Peninsula from 145° West longitude to 172° West longitude are evident. Both of these conditions show considerable changes in the oceanographic conditions in this region since the commencement of the INPFC investigations.

Plankton Investigations

During the past year, a planktologist was added to the oceanographic staff, and plankton collections obtained in previous years are being analyzed in terms of oceanic distribution, relation to hydrographic features and relation to salmon stomach contents.

Although more detailed data will be required to clarify relationships between plankton data and salmon catches, analyses of the 1959 trawl samples show that the distribution of immature red salmon south of the Aleutian Islands in August, 1959, may be related to the abundance of plankton.

Since 1955, large numbers of immature red salmon have been caught during August south of the Aleutian Islands. Assuming that at this time these salmon are moving westward in the coastal current and feeding, one would expect to find them in water identified by T-S envelope 3. However, as shown in Figure 19, although catches of 460 and 507 fish were made near the Aleutians, sizeable catches were also made in water identified by T-S envelope 2, or near the boundaries of envelopes 2 and 1. As shown previously, envelope 2 represents an upwelling zone between water identified as envelopes 1 and 3.

Figure 20 shows the wet weight in grams of samples collected after dark in the modified Isaacs-Kidd trawl. The trawl was towed at the surface at six knots for a period of 15 minutes. Because of the limited number of samples and inherent errors in plankton sampling, such as patchiness and vertical migrations, precise relationships cannot be expected. However, Figure 20 shows good evidence of a large standing crop of plankton in the region defined by envelope 2, where sizeable red salmon catches were made. The low values near the Aleutians may possibly be explained by grazing or by high surface velocities and turbulence associated with the coastal current. The low values

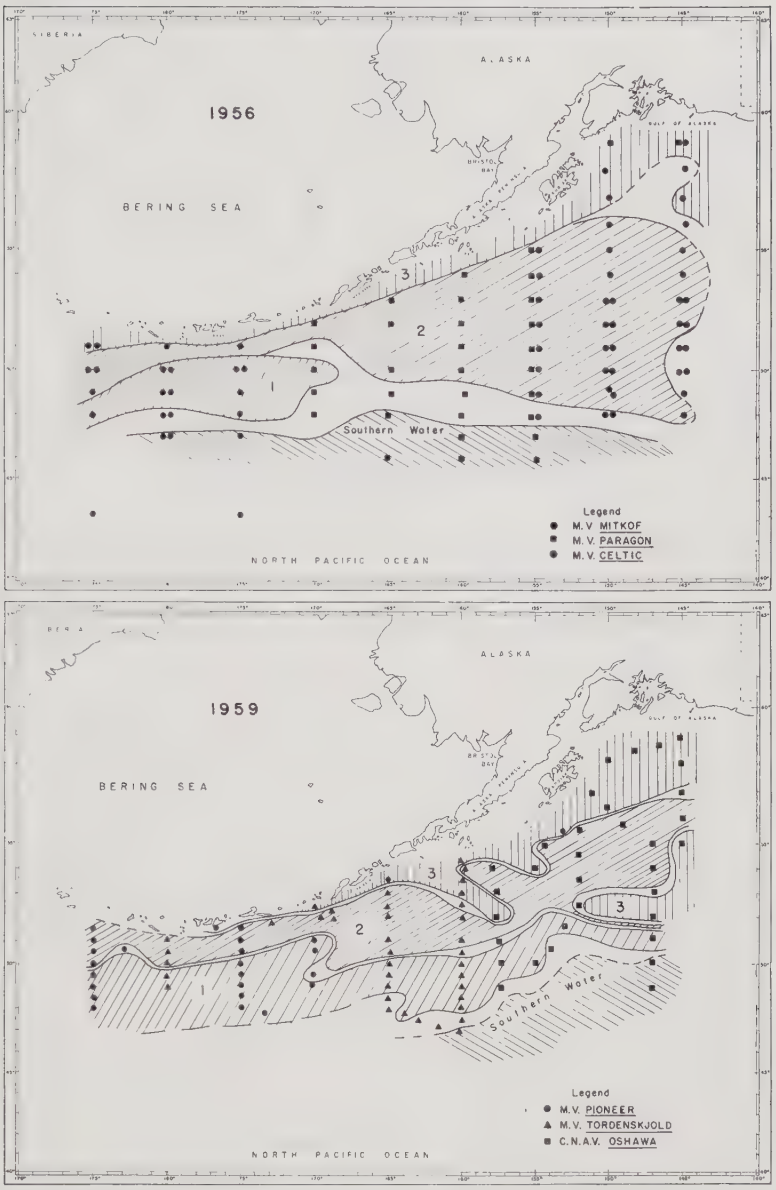

FIGURE 17. Geographical extent of Water Masses identified by T-S envelopes 1, 2 and 3 (indicated by hatching) in 1956 and 1959.

in the region defined by T-S envelope 1 are apparent, except for the value of 205 grams at 50° N., 165° W. It is interesting to note that at this station the sample consisted mainly of the copepod *Calanus cristatus;* whereas at all the other locations the euphausiid shrimps completely dominated the samples.

Further studies are required to ascertain the significance of the distribution and abundance of food organisms in relation to salmon movements.

REPORTS

During the past year a number of reports either have been published or submitted to the Commission.

Compilation of historical oceanographic data collected in the Bristol Bay region that had not been published was completed. The data collected in 1938 were published (Favorite and Pederson, 1958a) and those data obtained during 1939 to 1941 have been submitted for publication as a Special Scientific Report, (Favorite *et al.*, 1961a). The latter data were collected during the extensive purseseine and gillnet operations reported by Barnaby (1952), and will be used not only to compare environmental conditions with the results of fishing, but also to compare

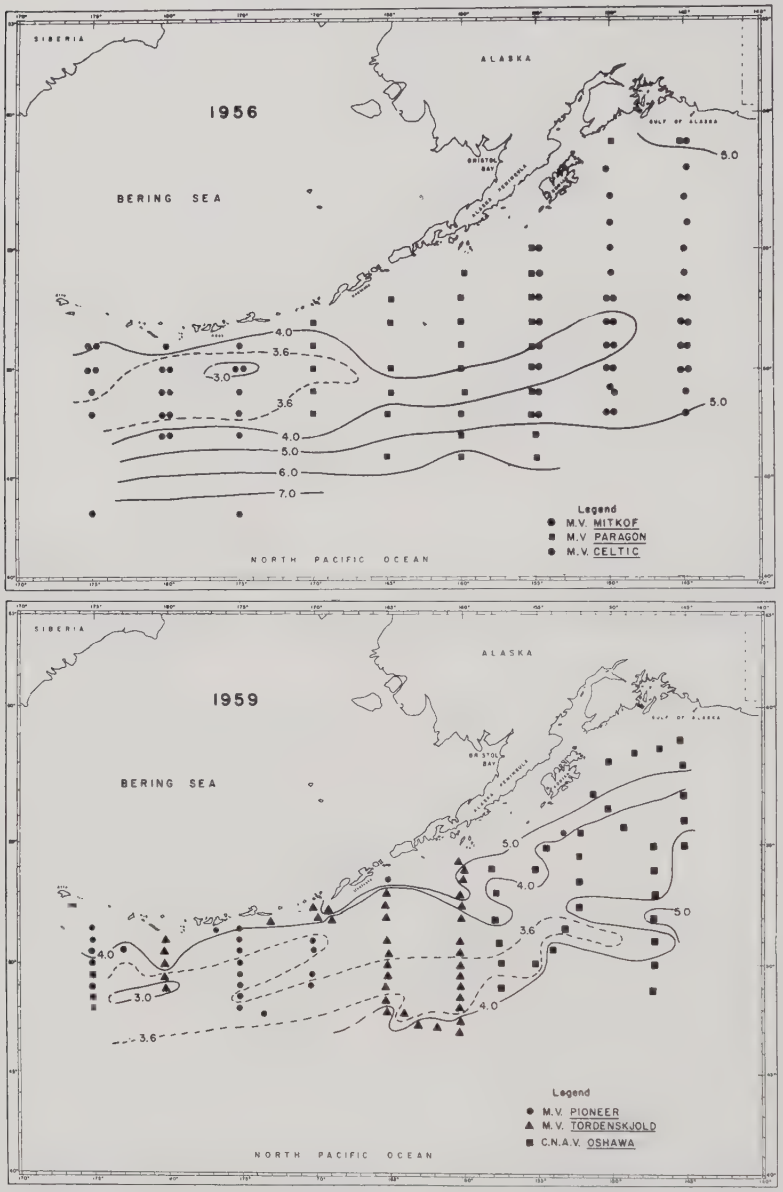

FIGURE 18. Temperature distribution (°C.) at 200 meters, 1956 and 1959.

previous conditions with those existing at the present time.

Love (1960) published the oceanographic data collected on board chartered research vessels in 1956. These data have been analyzed and utilized in a report by Favorite and Hanavan (1960) which presents relationships between oceanographic conditions and the distribution of salmons during spring and summer, 1956, and some relatively permanent oceanographic features that appear to affect the seasonal distribution of salmons.

Observations obtained aboard the chartered research vessels in 1957 were published (Favorite and Pedersen, 1959b). These data have been summarized in a report by Callaway (1960) which shows the oceanographic conditions in the vicinity of the Aleutian Islands during summer, 1957.

The 1958 observations were also published (Favorite and Pedersen, 1959c), and the data have been utilized in the construction of an oceanographic atlas (Dodimead and Favorite, 1960). The atlas comprises charts of vertical and horizontal sections of various properties across the North Pacific Ocean. The extensive data collected by Canadian, Japanese and United States agencies provide the most comprehen-

FIGURE 19. Numbers of red salmon caught in gill nets, August 1959.

FIGURE 20. Wet weights in grams of night surface trawls of 15 minutes duration, August 1959.

sive picture of the Subarctic Region ever presented.

The 1959 observations have been processed and submitted for publication (Favorite *et al.*, 1961b). Some use of these data is made in various sections of this report.

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STUDY ON SCALES

By Kenneth H. Mosher, Raymond E. Anas and Kenneth L. Liscom

Red Salmon

Study of the Basic Assumptions Underlying the Use of Scales for Red Salmon Racial Analysis

A study was designed to investigate the variations in the scale characters arising betwen different readers and between replicate readings by the same reader, as well as between and within localities. We have established that the variations between readers and between readings by the same reader and within localities is much less than that between localities. These results indicate a firm basis for the use of scale characters for racial analysis of red salmon. The results will be presented in detail in a later report.

Separation of Red Salmon to Continent of Origin

The progress report presented at the 1959 Annual Meeting (INPFC Doc. 312) gives the background information and procedures for analysis of the data for the 1956 and 1957 seasons. Additional fish have been processed and new bivariate charts computed. The high seas fish from the samples for 1956 and 1957 have been reassigned to continental origin using these more complete data.[1] Similar techniques have been applied to the samples collected in the central North Pacific and Bering Sea from mid-May to mid-July, 1958.

Methods of collection of samples, mounting and processing the scales to obtain the scale character data were essentially unchanged from the earlier study. For the 1958 samples, scale cards were made and counts of the circuli noted. Since we have found little error in counting the circuli of the more distinctly

[1] This has changed some of the preliminary results reported in Document 312.

marked ocean zones, on the second reading only the circuli of the freshwater zone were recounted. If in agreement with the original reading, and if the position of all annuli on the projection agreed with those on the card, the counts were accepted. If, however, there were differences, the scale was subjected to a conference study as noted for the 1956 and 1957 data.

Selection of Continental Standards

Nothing occurred in the course of the 1958 season to alter our conclusion that the predominant North American contributor to the red salmon of the North Central Pacific and Bering Sea, as in the two previous seasons, was Bristol Bay. Tagging results also confirmed this conclusion as they had in the past; therefore, Bristol Bay samples were used to define the western Alaskan type with the addition of Karluk River samples for the 4-year freshwater ages. As in 1957, samples taken as close as available to the coast and in the Okhotsk Sea were used to represent the distribution of Asian characters. For this study, four samples taken in the area from 49° to 52° North latitude and 159° to 167° East longitude and four samples in the Okhotsk Sea were used. One sample taken at 48° 55′ N. and 156° 28′ E. was held back to use in verifying the error of misclassification computed from the other data.

Procedures for Separation of Continental Groups

As with the two and three-year freshwater ages in the 1957 season, separate bivariate frequencies of the number of circuli in the first ocean zone tabulated against the number of circuli in the total freshwater zone were made for the western Alaska and the Asian inshore samples. For the four-year freshwater group, the size of the same two zones was used. This provided a series of six separate tabulations. The fish were divided according to whether they had spent two, three, or four years in fresh water and whether they were from Asia or western Alaska. Each of the six frequency tabulations was then weighted to 100 to adjust for varying sample size. For each freshwater age, the Asian bivariate frequency was then superimposed on the one for western Alaska and an additional chart made where the predominant group in each cell of the tabulation was indicated: "A" for predominantly Asian and "N" for predominantly western Alaska.

There were some cells in the charts which had no fish. In case a fish from an unknown area had characters which fell in these cells, the fish was arbitrarily assigned to the area shown by the adjacent cells in a vertical column. If the adjacent cells did not show the same origin or if the adjacent cells were vacant, no determination was made. This was a small percentage of the high seas samples. Figures 21, 22, and 23 show these charts for the two-year, three-year, and four-year freshwater ages, respectively.

These charts were then used to classify the fish from the high seas samples for 1958 using the procedures described in the 1956–57 report.

If more than one sample was available in a general

Number of circuli in first ocean zone

Number of circuli in total freshwater zone	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
7				A	A		A	A	A	A	A	A	A	A				
8						A	A	A	A	A	A	A	A	A				A
9					A	A	A	N	A		A	N		N		N		
10						A	A		A	A	A	A	A	A	A		A	
11						A	N	N	A	A	A	A	N	N	A	A		
12							N	A	A	N	N	A	A	A	A		A	
13							A			N	A	A	N	N				
14				A	N		N	A	A	A	N	A	A	A	A	A	A	
15					A	N	N	A	N	N	N	N	A	N	A			
16				N	N	N	N	N	N	N	N	N		A	A	A	A	
17			N	N	A	N	N	N	N	N	N	N	N	A		A	A	
18			A	N	N	A	N	N	N	N	A	A	A		A			
19	A			N	A	N	N	N	N	N	A	N	N	N	A	A		
20					N	A	N	N	A	A	N	A	A	N	A	A		
21		N	N	N	N	N	N	N	N	A		A			A	A		
22						N		N	A	N	N	A	A					
23							A							A				
24													A					

FIGURE 21. Continental classification chart, 2-year freshwater fish, 1958. "A" Classify as Asian, "N" Classify as western Alaskan.

Number of circuli in first ocean zone

Number of circuli in total freshwater zone	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
9													A					
10											A							
11								A	A	A	A	A			A			
12			A						A	A	A	A	A	A				A
13					A	A	A	A	A	A	A	A		A	A	A		
14							A	A	A	A	A	A	A	A	A	A		
15			A	A	A	A	A	A	A	A	A	A	A	A			A	A
16				A		A	A	A	A	A	A	A	A	A	A	A		
17		N		A	N	A	N	N	A	A	A	A	A	A	A	A	A	
18				N	N	N	N	N	N	N	A	A	A	A	A		A	
19					N	N	N	N	N	A	A	A	A	A	A	A	A	
20			N	N	N	N	N	N	N	A	N	A	A	A	A			
21			N	N	N	N	N	N	N	N	A	A	A	A			A	
22		N	N	N	N	N	N	N	N	N	N	A	A	A				
23			N	N	N	N	N	N	N	N	N	N	N	A	A			
24				A	N	N	N	N	N	N	N	A	A			A		
25			A				N	A	A	N	N	N		A				
26				N			N	A	A		N		A	N	A	N		
27						A	A		A									
28		N	A	A	A	N	A	A	A	A		A						
29			A	A			A	A			A	A						
30				A	A		A	A	A	A	A							
31				A			A	A	A	A								
32							A	A	A									
33				A		A		A	A									
34					A	A	A	A		A	A							
35						A												
36							A		A									

FIGURE 22. Continental classification chart, 3-year freshwater fish, 1958. "A" Classify as Asian. "N" Classify as western Alaskan

Size of 1st ocean zone in mm. of projected image

Size of total freshwater zone	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
16														A									
17				A		A		A		A	A				A				A				
18		A	A	A	A	A	A	A		A	A	A	A				A		A		A		
19			A				A		A	N	A	A	A			A				A			
20	A				A		A	A			A	A	N	A	A	A		A		A			
21			A	A		A	A	A		A	A	A	A	A	A	A	A		A		A		
22				N	A	A		A	A		A	A	A	A	A	A			A	A			A
23	A	A	N	A	A		A	A	A	A	A	A	A	N	A	A	A	A	A	A			
24			N	A	N	N	N	A	A	A	A	N	A		A	A	A	A		A		A	
25		N	N	N	N	A	A	A	N	N	A	N	A	A	A	A	N	A	A				
26				N		N	A	N		N	A	N	N	N	A	N	A	A	N				
27					N	N	N	A	A	N	N	A	N	A	A		A	A	A	N	N		
28						N	A		N	N	N	N	N	N	N	A	A		N	A		N	
29		N	N		N		N	A	N	N	N	N	N	N	N	N	N					A	
30			N	N	N	N	N	N	A	N	A	A	N	N	A	N	N	A			N		
31	N				A		N		N	N	N	N	A	A	A	N	N			N			
32					A	N		N	A	N	N			N	N		N						
33				N					N		A	A				A	N						
34									N				A										
35								N			N												
36																							

FIGURE 23. Continental classification chart, 4-year freshwater fish, 1958. "A" Classify as Asian. "N" Classify as western Alaskan.

TABLE 3. Continent of origin of high seas samples, May 16 to July 15, 1958.

Fishery or vessel	Locality		Date	No. N.A.	No. Asian	Per cent N.A.	Adjusted Percent N.A.[1]
	Latitude	Longitude					
Japanese high seas	49°21′N	173°19′E	5/16	30	33	47.6	33.8
〃	50°10′N	168°15′E	5/16	40	58	40.8	21.6
〃	47°30′N	169°41′E	5/26	22	75	22.7	00.0
MV *Pioneer*	53°00′N	180°00′	5/28				
〃	53°00′N	180°00′	6/17				
MV *Attu*	52°04′N	178°38′W	7/12	30	12	71.4	76.6
〃	52°31′N	179°59′W	7/13				
〃	53°31′N	180°00′	7/14				
MV *Attu*	51°00′N	180°00′	5/28				
MV *Pioneer*	50°22′N	177°45′W	7/10	34	29	54.0	45.3
〃	50°59′N	178°50′E	7/12				
〃	50°18′N	177°08′E	7/13				
MV *Pioneer*	53°00′N	178°15′E	5/29				
〃	54°00′N	180°00′	6/18	28	12	70.0	74.1
〃	54°43′N	178°14′E	6/22				
MV *Attu*	54°00′N	178°00′E	7/15				
Japanese high seas	51°05′N	171°30′E	5/29	57	129	30.6	3.2
〃	52°02′N	171°35′E	6/ 5				
MV *Attu*	50°00′N	180°00′	5/29				
〃	49°00′N	180°00′	5/31	27	22	55.1	47.3
MV *Pioneer*	50°00′N	180°00′	6/30				
MV *Pioneer*	55°00′N	174°00′E	5/31				
〃	54°00′N	173°00′E	6/ 1	15	11	57.7	52.0
〃	53°00′N	172°00′E	6/ 2				
Japanese high seas	50°50′N	172°30′E	6/ 7	65	55	54.2	45.7
MV *Pioneer*	51°35′N	173°00′E	6/ 8				
Kano-maru	59°00′N	171°00′E	6/11				
〃	59°28′N	170°54′E	6/12	11	10	52.4	42.4
〃	59°20′N	170°51′E	6/13				
〃	59°16′N	169°03′E	6/17				
Japanese high seas	50°41′N	167°14′E	6/15	18	68	20.9	0.0
MV *Attu*	53°00′N	170°00′W	6/17	40	9	81.6	95.0
Wakashio-maru	56°00′N	172°30′W	6/18	62	12	83.8	98.9
〃	56°00′N	172°50′W	6/19				
Kano-maru	59°02′N	167°00′E	6/21				
〃	58°00′N	166°00′E	6/22	11	15	42.3	24.3
〃	58°00′N	166°00′E	6/25				
〃	58°00′N	166°00′E	6/26				
MV *Attu*	55°00′N	167°00′W	6/24				
〃	55°04′N	169°24′W	6/25				
〃	55°58′N	170°04′W	6/26	65	21	75.6	84.1
〃	56°57′N	168°58′W	6/27				
〃	57°59′N	169°59′W	6/28				
MV *Pioneer*	51°17′N	175°53′W	7/ 6				
〃	50°30′N	175°00′W	7/ 7	29	21	58.0	52.5
〃	49°30′N	175°00′W	7/ 8				

[1] Formula for adjusting percentages to correct for misclassification error:

$$F_a = \frac{K_a - P_b}{1 - (P_a + P_b)}$$

where F_a = adjusted percentage western Alaska type fish,
K_a = observed percentage of western Alaska type fish,
P_a = misclassification error of western Alaska type fish (15.6 per cent),
P_b = misclassification error of Asian type fish (28.8 per cent).

area during the period of fishing from mid-May to mid-July, when the large fish were predominant in the catches, the percentages were computed on the combined totals. Combined area samples of less than 20 fish were not included. The results of this classification are shown in column 7 of Table 3.

Estimation of Errors of Classification

By treating the fish of the inshore areas as unknowns and classifying them to continent of origin with the charts, an estimate of the errors inherent in the application of these charts to the 1958 data can be obtained. For the western Alaska samples, the errors averaged 15.6 per cent; the Asian, 28.8 per cent (Table 4). Individual sample errors for western Alaska varied between 8.9 and 22.2 per cent; those of the Asian side, between 15.1 and 40.6 per cent.

Table 4. Accuracy and misclassification error of reference samples, 1958.

Locality		Date	No. N.A.	No. Asian	Percentage		Average error
Latitude	Longitude				Accuracy	Error	
Asian							
Okhotsk Sea							
51°08′N	153°45′E	6/15	23	74	76.3	23.7	
51°09′N	153°40′E	6/25	33	70	68.0	32.0	
50°49′N	153°07′E	7/ 5	40	66	62.3	37.7	
51°39′N	154°10′E	7/15	41	60	59.4	40.6	
Total			137	270	66.3	33.7	33.5
Southeast Kamchatka							
49°21′N	160°27′E	6/16	33	65	66.2	33.8	
49°35′N	166°35′E	6/25	14	79	84.9	15.1	
50°35′N	159°50′E	7/19	30	79	72.5	27.5	
51°58′N	159°51′E	7/26	23	91	79.8	20.2	
Total			100	314	75.8	24.2	24.2
Total Asian			237	584	71.2	28.9	28.8
Western Alaska							
Ugashik		7/16	106	21	83.5	16.5	
Egegik		7/ 7	136	22	86.1	13.9	
Naknek		7/9, 13, 14	153	26	85.5	14.5	
Kvichak		7/10, 16, 24	287	82	77.8	22.2	
Wood River		7/4 & 5	134	29	82.2	17.8	
4-yr. freshwater fish (chiefly Karluk)		6/26 & 8/31	72	7	91.1	8.9	
Total Western Alaska			888	187	82.6	17.4	15.6
Average all samples					78.3	21.7	

Impression copies of scales including red salmon from three Kamchatkan Peninsula rivers in 1958 were kindly made available to us by the Japanese Fisheries Agency. Classifying these fish, using the bivariate charts, gave the following results:

Bolshaya River—89.5 per cent of 86 usable scales were correctly classified to Asian origin (error 10.5 per cent),

Blijinyaya River—95.5 per cent of 133 scales were correctly classified (error 4.5 per cent), and

Dalinyaya River—58.2 per cent of 158 scales were correctly classified (error 41.8 per cent).

The average for the three streams was 18.9 per cent error.

The fish from the Dalinyaya River, which includes Dalnee Lake, experience good growing conditions (Krogius, 1958). The scales reflect this by showing a large freshwater growth zone with numerous circuli. While some of these scales are distinct from any on the American side of the Pacific, a substantial number overlap the frequency of similar characters of some of the Bristol Bay fish, accounting for the greater error found in classifying these fish.

Both the Dalinyaya and Blijinyaya Rivers are tributaries of the Paratunka River which, along with the Bolshaya River, are actually of minor importance in Asiatic red salmon production in relation to the Ozernaya and Kamchatka Rivers, for which no 1958 samples are available to us.

As mentioned earlier in the paper, one sample, taken near the southeast Kamchatka area from which were taken the samples used in computing the Asian char-

acters, was held back for independent use in verifying the misclassification error. Fish of this sample taken July 5, 1958, at 48° 55′ N. latitude and 156° 28′ E. longitude were classified to continental type with an overall accuracy of 80.2 per cent (error 19.8 per cent) out of 106 fish.

Both these objective tests, the classification of fish from the Kamchatka Peninsula rivers and the sample from the same area as the Asian standards, indicate that the average misclassification errors fall within the range observed for the Asian standards; consequently, the average of 28.8 per cent has been used as the basis of the adjustment for the Asian type fish, and 15.6 per cent for the western Alaskan type.

The high seas samples were adjusted using the formula

$$F_a = \frac{K_a - P_b}{1 - (P_a + P_b)}$$

where:

F_a is the adjusted percentage of western Alaskan type fish,
K_a is the observed percentage of western Alaskan type fish,
P_a is the average error of misclassification of western Alaskan fish (15.6 per cent),
P_b is the average error of misclassification of Asian fish (28.8 per cent).

The results of this adjustment are shown in column 8 of Table 3 and Figure 24.

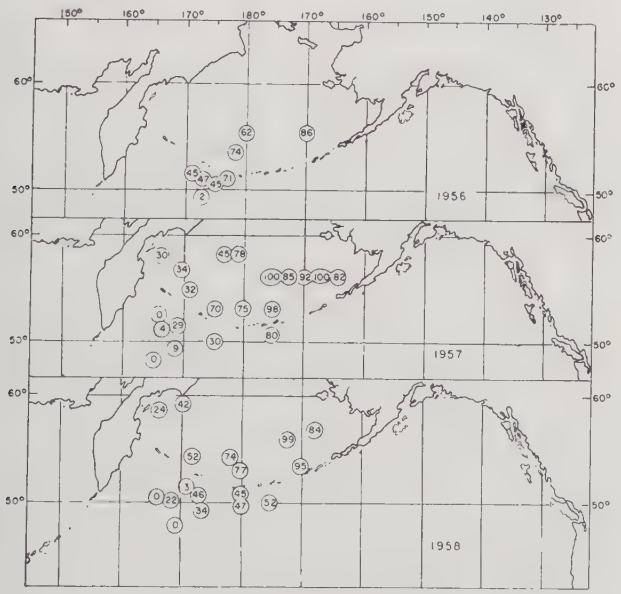

FIGURE 24. Adjusted percentage distribution of western Alaska type red salmon in samples from central North Pacific-Bering Sea areas from mid-May to mid-July, 1956 to 1958.

Discussion

For comparison, the charts showing the adjusted percentage distribution of the western Alaskan type fish as found by classifying individual fish in the high seas samples for 1956 and 1957 are also included in Figure 24.[1]

Examination of this figure does not show any great differences in the distribution of the western Alaska type fish in the Bering Sea from the start of fishing in May to mid-July. During this period when the larger fish predominate, the distribution has been essentially the same for the three years for which data are available. Differences in the time and location of fishing and in sampling coverage have induced some differences in detail. In the North Pacific Ocean, the westward extent of large numbers of western Alaska red salmon seems to have been more variable.

Intermingling of the stocks from Asia and western Alaska over a wide area from at least longitude 175° W. to 170° E. is indicated. In 1957 and 1958, the years with the most complete coverage north of the Aleutian Islands, western Alaska stocks were found along and north of the Aleutians and appeared to predominate in the catches westward to near longitude 175° E. Farther to the north near latitude 58° N., western Alaska stocks appeared to predominate to just westward of longitude 180° in 1957. South of the Aleutian Islands in 1958, when coverage in this area was the most complete, Asian stocks appeared to predominate from the Asian coast eastward to between longitudes 180° and 175° W. In 1957, Asian fish predominated at longitude 175° E. and western Alaska fish at 175° W.

Additional Information on the Distribution of Continental Stocks

Again, as in the previous years, the need to know more about the stocks of red salmon south and east of the Aleutians from about 175° E. longitude into the Gulf of Alaska becomes increasingly apparent. The reduction of western Alaska type fish as we sample southward from the Aleutians is a cause for speculation. This has also been noted by Kubo (INPFC Doc. 326).

We do know that some of the fish originating in the area south and east of Unimak Island have numbers of circuli in the freshwater and first ocean zones similar

[1] This figure shows the distributions for 1956 and 1957 obtained by reclassifying the individual fish according to the complete bivariate tables and by regrouping the samples to include at least 20 fish. This corrects Figures 25 and 26 shown on page 94 of the INPFC Annual Report for 1959.

to some of the Asian fish. If these intermingle with Asian fish and fish from Bristol Bay in the area south of the Aleutians between 175° E. and 175° W. longitude, they would be classified in error to Asian origin. A search is under way for characters which will separate these fish from Asian fish.

It has been known for many years that certain scale types were characteristic of certain areas. Dr. Gilbert called attention to the unique character of the Rivers Inlet scales as long ago as 1913 (Gilbert, 1914). In this paper he said, " The accompanying figures make evident this peculiarity, which is so marked that scales from any ten sockeye from Rivers Inlet taken at random could easily be distinguished from an equal number from any other river-basin known to us." We have recognized these scales as well as ones from Fish Creek in Cook Inlet and Lake Dalnee on the Kamchatka Peninsula, among others. While we have not as yet reduced the characters of these visually identifiable scales to a formula, we have noted any which we have recognized in the samples as they are studied.

Figure 25 shows the high seas locations where fish identified visually as from Rivers Inlet, Fish Creek or

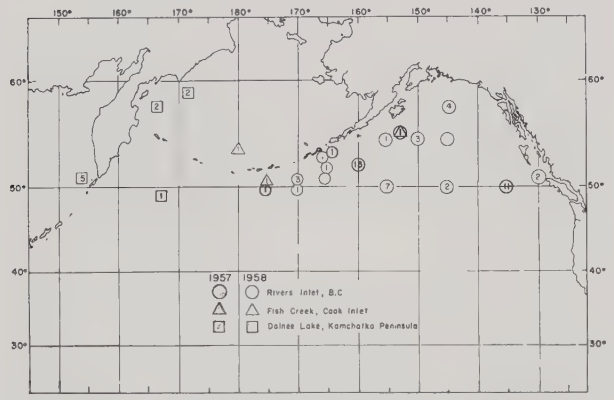

Figure 25. Location and number of fish having visually identifiable scales found from May to September, 1957 and 1958.

Dalnee Lake were observed, and the numbers identified at each location, during the sampling season from May to September in both 1957 and 1958.[1]

In both years, Rivers Inlet fish were found in a number of samples in the Gulf of Alaska—in 1957, from longitude 175° W. eastward, and in 1958, from longitude 170° W. eastward. In 1957, one Fish Creek scale was observed just south of Kodiak Island, and in 1958, one was found at longitude 175° W. south of Atka Island and one at 180° north of the Aleutians. In 1957, one Dalnee Lake scale was seen in a sample taken near 49° N. latitude and 167° E. longitude, while in 1958, a number were observed in three samples taken close together in the Okhotsk Sea and from samples in the Olyutorskii and Karaginski areas.

Scales from Lake Dalnee fish were found only in areas in which Asian stocks were predominant according to the bivariate classification (see Figure 24). Scales from fish from Rivers Inlet and Fish Creek were found only in the Gulf of Alaska samples, except for three which occurred in samples in which western Alaska stocks predominated.

[1] The number and location of Rivers Inlet fish shown in Figure 25 differ somewhat from those shown in Figure 1 of Manzer (1960) since the samples examined for the two figures were not identical.

References

Gilbert, Charles H.
1914. Contributions to the life history of the sockeye salmon. No. 1. Report of the Commissioner of Fisheries for year ending December 31, 1913. *Province of British Columbia*, pp. R53 to R78, illust. Victoria, B.C. 1914.

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1958. On the scale pattern of Kamchatka sockeye of different local populations. (O stroenii cheshui Kamachatskoi krasnoi raznykh lokalnykh stad) published by *Vsesoiuznyi Nauchno-Issledovatelskii Institut Morskovo Rybnovo Khosiaistva i Okeanografii* (VNIRO), Moskow. *Fisheries Research Board of Canada Translation Series*, No. 181. Translated by R. E. Foerster, Nanaimo, B.C.

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1959. Study of sockeye salmon stocks by means of the growth pattern of scales. *INPFC Doc.* No. 326.

Manzer, J. I., T. H. Bilton, and K. H. Mosher.
1960. Ocean distribution of sockeye salmon originating in Rivers and Smith Inlets. *Fisheries Research Board of Canada, Manuscript Report Series* (Biological) No. 702. Nanaimo, B.C., Dec. 1960.

Mosher, Kenneth H.
1959. Racial analysis of the offshore samples of red salmon from the central North Pacific and Bering Sea from May 1 to July 15, 1956 and 1957 by means of scales. *INPFC Doc.* No. 312.

Pink Salmon

Analysis of meristic and scale data collected in 1957 showed that the characters used, i.e., total number of vertebrae, number of dorsal fin rays and length of the scale to the tenth circulus (the intermediate scale length), could separate the Asian and American stocks north and west of Kodiak Island from the Ameri-

can stocks to the east and south.[1] However, these characters were not efficient in separating the more northerly American stocks from those of Asian origin. While most of the American stocks of pink salmon in the Bering Sea and along the Aleutians are not large individually, there are many streams, so that in some years the sum of the stocks is substantial. Thus, it became necessary to try to find one or a combination of characters which would separate fish from these critical areas from the Asian fish.

Before attempting to find more efficient characters for separating the continental groups in the critical area, a study of the source of the variations in scale characters was made. Standards were developed for precisely describing the position of the annulus and for counting complete and broken circuli. It was found that the longest radius of the completed growth zone, measured from the outermost edge of the first circulus from the center as the base rather than the center of the focus, gave the most readily reproducible measurement and counts of circuli.

The standards developed by the above study were further tested in a second study in which ten scales were picked at random from areas close to the Bering Sea and the Alaska Peninsula using 1957 data. These scales were read and replicate readings were made a few days later. None of the interactions or replicate mean squares were significant, showing that the reader could repeat his readings satisfactorily. The error term was composed of the variation of scales within areas.

After the reproducibility of the data and the procedures to use in obtaining the scale characters had been established, a test was devised to investigate the suitability of characters for use in separating Asian and American pink salmon. Six scales were selected at random from the 1958 samples for each of 14 critical areas that included six samples from Siberian rivers flowing into the Okhotsk Sea. These scales were read separately by three readers with replicate readings made several weeks later. The following characters were used:

1. Number of circuli from the focus to the outermost edge of the annulus.
2. Number of circuli in the first half of the distance from the outermost edge of the center ring to the annulus.
3. Narrowest band of three circuli interspaces, either circuli 4 to 7 or 7 to 10.
4. Length of scale from the center ring to the sixth circulus.
5. Length of scale from the center ring to the tenth circulus.
6. Length of scale between the fourth and tenth circuli.
7. Length of scale four interspaces outside (beyond) the annulus.
8. Length of scale four interspaces inside the annulus.
9. Length of scale to the outermost edge of the annulus.

The results of this test are not yet complete; however, a comparison of the means from the first readings indicates that scale characters may be found which will separate the 1958 samples by continent of origin. Number of circuli in the first half of the scale length to the annulus and number of circuli from the center of the scale to the annulus appear upon preliminary examination to be the characters offering the greatest separation between the American and Asian fish.

For the 1957 and 1959 samples, the problem appears more complex. The list of characters now under study provides no better separation than the original characters used in the discriminant analysis of the 1957 data. Scale and meristic data, however, appear to separate the continental stocks more satisfactorily in 1959.

Chum Salmon

The chum salmon scale collections through 1959 which have been processed here at the laboratory have been aged for use in meristic studies. We are now engaged in a comprehensive study to test the variations between readers, between replicate readings by the same reader, within and between localities, and to test the variations between scale characters. The results of this investigation will assist us in establishing our procedures for obtaining the scale characters and in choosing the characters with the greatest separation between the areas likely to furnish fish to the central North Pacific and Bering Sea. We plan to combine the most distinctive scale characters with the best meristic characters into a procedure for discriminating between the fish of the two continents.

[1] Use of a discriminant function in the morphological separation of Asian and North American races of pink salmon, *Oncorhynchus gorbuscha* (Walbaum). Amos, M. H., R. E. Anas, and R. E. Pearson. INPFC Doc. 412.

SEROLOGY

By George Ridgway

The problem of determining the extent of intermingling of Asian and American stocks of salmon in high seas areas as outlined in the protocol of the INPFC has been approached in several ways. Among these approaches have been the use of various serological or immunochemical methods to search for characteristic differences in the antigenic constitutions of the populations involved.

Because of the complexity of the problem, and the difficulty in obtaining fresh whole blood from Asian and high seas areas, the search for antigenic differences has been applied not only to blood cell antigens, but to serum antigens and the soluble antigens extractable from tissue as well.

Research on Blood Cell Antigens

Our previous research in the field of red cell antigenic differences has been described in two papers:

Ridgway, Cushing and Durall.
Serological differentiation of populations of sockeye salmon (*Oncorhynchus nerka*). *U.S. Fish and Wildlife Service, Special Scientific Report:* Fisheries, No. 257. August 1958.

Ridgway and Klontz.
Blood types in Pacific salmon. *U.S.Fish and Wildlife Service, Special Scientific Report:* Fisheries, No. 324. January 1960.

In the 1960 season, several new sources of possible blood grouping reagents were investigated, in addition to certain of those already reported on. Additional mammalian sera, the sera of several species of fish and aquatic invertebrates, and extracts from the seeds of a number of leguminous plants were tested for their hemagglutinating activity with red blood cells of red and pink salmon. Such normal sera and legume seed extracts have been demonstrated to be possible sources of blood grouping reagents with humans or other animals.

Tables 5 and 6 present summaries of the work we have done this year in search of natural sources of blood typing reagents. Some of the legume extracts are very promising and have the advantage that the reagent can be taken on board a vessel or into the field in the very stable form of dried seeds. These methods appear very promising, but further research will be required to determine their utility in distinguishing between Asian and American stocks of salmon.

Table 5. The hemagglutination reactions of various animal sera with the red cells of two species of salmon.

Hemagglutinin source	Salmon Species Red	Pink
Mammalian sera		
Cattle serum 1	+	–
〃 2	+	–
〃 3	+S	–
〃 4	+	–
〃 5	+	–
〃 6	+	–
〃 CA2	+P	+P
〃 3562	+P	+P
Pig serum 1	+P	+P
〃 2	+	+
〃 3	+	+
Sheep	+P	–
Bird sera		
Chicken anti-red salmon hematopoetic organs (7 individuals)	+S	–
Fish sera		
Halibut (10 individuals)	0	–
Carp (3 individuals)	0	–
English sole	+	+
Pacific cod	0	0
Sebastodes (2 species)	0	0
Marine and freshwater invertebrate sera		
Crayfish serum (pool)	0	
Dungeness crab serum (2 individuals)	+	+
King crab (2 individuals)	+S	+

(+) Reacts but no individual differences detected.
(+P) Detects some apparent individual differences. Promising source of blood typing reagent for species of salmon tested.
(+S) Some individual differences noted but not a promising source of reagent because differences not clear cut.
(0) No reactions with any individuals tested.
(–) Not tested.

Research on Soluble Tissue Antigens

Because of the logistic problems involved in taking blood samples from fish on the high seas, research was initiated to study soluble tissue antigens, extractable from the muscle of frozen whole salmon. This research has been concerned with the factors involved in stabilizing the extracts, the production of potent antisera, the factors involved in obtaining reproducible results, the extent of cross-reactivity among the soluble tissue antigens of various fishes and the search for differences between species and individuals.

TABLE 6. The hemagglutination reactions of legume seed extracts with the red cells of red and pink salmon.

Legume seed extract	Salmon Species Red	Pink
Phaseolus limensus var "Baby Lima"	+P	+S
" " "Large Lima"	0	−
" " UC L5	+P	+
" " UC, L 26, 126, 75	0	0
" " UC, L 35, 48	+P	−
" " UC, L 59, 186	+P	0
" " UC, L 100	+	
" " UC, L 191	+S	−
UC = Univ. of California Agricultural Experiment Station. Stain kindly supplied by Dr. R. W. Allard.		
Phaseolus vulgaris var "Green Stringless"	+	+
" " "Golden Wax"	+	+
" " "Red Kidney"	+	+
" " "California White"	+P	−
" " "Idaho Red"	+P	−
" " "Pinto"	+S	−
Phaseolus multiflora	+	+
Lens culinaris	0	0
Pisum sativum	0	0
Glycine soja	0	0
Cicer arietinum	0	0
Cytisus scoporus	0	0
Cytisus austraicus	0	0
Cytisus barkwoodii	0	0
Ulex europeous	0	0
Laburnum alpinum	0	0
Laburnum anagyroides	0	0
Laburnum vossii	0	0
Colutea orientalis	0	0
Colutea persica	0	0
Colutea gracilis	0	0
Colutea sp. (fresh green seeds)	+	+
Vicia americana	0	0
Vicia gigantica	0	0
Vicia faba	0	0
Caragana sp.	+	+
Caragana macrophylum	+	+
Lupinus sp.	+	+
Robinia pseudoacacia	+	+
Robinia hispida	+	+
Robinia viscosa	0	0
Maackia amurensis	+	+

(+) Reacts but no individual differences detected.

(+P) Detects some apparent individual differences. Promising source of blood typing reagent for species of salmon tested.

(+S) Some individual differences noted but not a promising source of reagent because differences not clear cut.

(0) No reactions with any individuals tested.

(−) Not tested.

It has been found that the extracts are relatively stable if prepared in 50 per cent glycerol and kept at low temperatures (4° C.). Potent antisera have been produced consistently in both rabbits and goats through the use of adjuvants. Reproducible results are obtained if the temperatures of extraction and testing are kept cold. Cross-reactivity appears to be greater in the case of soluble tissue antigens than in the case of serum antigens. For example, considerable cross-reactivity occurs when the soluble tissue antigens of tuna are tested with rabbit anti-salmon tissue, while virtually no cross-reactivity occurs between the serum antigens of these groups. The distinction of salmon species appears to be possible through the application of immunochemical methods to their soluble tissue antigens, but no individual differences have been found. Consequently, this approach does not appear to offer much promise for racial identification, at least at its present state of development.

RESEARCH ON SERUM ANTIGENS

Because the problems involved in preserving and transporting salmon blood samples from Asian and high seas areas made it virtually impossible to obtain intact red blood cells, a study has been made of serum antigens. Previous results of this study have been submitted for publication; Ridgway, Klontz and Matsumoto, "Individual Differences in the Serum Antigens of Red Salmon" (INPFC Doc. 313).

Antigens designated I and II were found to be present in 95 to 98 per cent of red salmon blood samples tested from American areas and absent from 85 to 90 per cent of red salmon blood samples tested from Asian areas. Intermediate frequencies of occurrence were found in red salmon blood samples taken in areas north and south of the Aleutian Islands in 1957 and 1958.

As pointed out in the manuscript describing these results in detail, several important difficulties have been encountered in the application and interpretation of these results. The first is the difficulty in producing large quantities of antisera which are potent and specific for the particular differences noted. The second difficulty involves interpretation of the results, since there was some apparent disagreement between the results obtained with this method and those obtained by other methods. Specifically, some of the red salmon blood samples obtained in the Bering Sea east of 180° were negative for these antigens and would thus be classed as Asian fish. Other methods have classified nearly all of the red salmon in the Bering Sea east of 180° as American.

These problems were investigated extensively in the past year but ready solutions were not found. Since previous experience had shown that only one rabbit out of eight immunized could be expected to produce useful antisera, considerable attention was paid to the use of different methods of immunization that have proven useful in other immunological research. In order to accomplish this, the immunization program was increased considerably with forty-five rabbits immunized and the effect of several variables studied. Only a few of the resulting antisera showed promise as reagents for detecting antigenic differences between Asian and American salmon. The use of pooled samples, partially purified serum samples fractionated by ammonium sulfate precipitation, the use of alum precipitated serum, and serum incorporated in Freund's adjuvant all decreased, rather than increased, the yield of antisera potent and specific for antigens I and II. Thus, it appears that the original methods of immunization are still the best available at the present level of knowledge concerning the nature of the antigens involved.

The few promising antisera produced were used to test 303 red salmon blood samples taken from American shore areas, 183 taken from high seas areas west of 170° E., and 695 from high seas areas east of 170° E. Unfortunately, these antisera were too weak to give consistent results. We feel it is essential to make a more thorough study of the nature of the difference being detected, and the effect of such variables as may be introduced by sampling and preservation methods, before further application of this method is possible. It will also be essential to perfect methods for the consistent production of large quantities of potent and specific antisera.

In contrast to the difficulties involved in the test for antigens I and II are the results obtained with the antigenic complex found in the sera of mature or maturing females. Potent and specific antisera have been produced in both rabbits and goats using both whole serum and purified antigen. The antigen is very stable, being readily detectable in heart blood from frozen salmon.

Heart blood from 5,308 red salmon being processed by the morphology laboratory were tested for this character. A measure of the error involved in manipulation and labeling can be obtained from the fact that 2,536 males were tested, only 10 of which were scored positive (0.4%).

The results on female salmon are presented in Tables 7 and 8. Table 7 shows the relationship between the time interval in which red salmon were caught and the proportion of the females classified as maturing. These results indicate that this antigenic character is a reliable indicator of maturity in female red salmon as early as late April.

Table 8 shows the proportion of the total female red salmon sampled which were classified serologically as mature according to the source.

The results are being used to verify the criteria for maturity used by other investigations.

TABLE 7. The relationship between time of catch and the proportion of female red salmon sampled which were mature (as determined serologically).

Time interval of catch		Total number of females tested	Number classified as mature	Per cent classified as mature
April 27	May 15	13	13	100
May 16	May 31	321	300	93.5
June 1	June 15	732	709	96.9
June 16	June 30	693	617	89.3
July 1	July 15	415	320	77.1
July 16	July 31	301	57	18.9
August 1	August 15	241	27	11.2
August 16	August 21	56	7	12.5
Total		2,772	2,050	73.95

TABLE 8. Proportion of female red salmon sampled which are classified as mature, using serological methods.

Source	Total number of females tested	Number classified as mature	Per cent classified as mature
Hokkaido Gyogyo Kosha (Okhotsk Sea 1958)	281	281	100
Nippon Suisan K.K. (Western North Pacific and Bering Sea 1959)	332	291	87.6
Nichiro Gyogyo K.K. (Western North Pacific 1959)	302	227	75.2
Japanese research vessels 1959	314	130	41.4
United States research vessels 1959	1,547	1,114	72.0

ANALYSIS OF RED SALMON MORPHOLOGICAL DATA—1958 AND 1959

By F. M. Fukuhara

Since 1955, specimens have been collected and examined to determine the degree to which Asian and North American red salmon could be separated using differences in morphological characters. Analysis of data from collections of red salmon taken in 1955 through 1957 were presented in International North Pacific Fisheries Commission (INPFC) Document No. 320. Seven characters were selected as indices for racial separation and, on the basis of certain *a priori* information, a discriminant function was constructed using the 1956 Okhotsk Sea and western Alaska samples as reference morphotypes.

Applying the classification criterion derived from this function to the 1957 collections obtained from western Alaska and southwest Kamchatka, it was shown that the actual errors of misclassification very closely approximated the expected error of misclassification inherent to the function. On the strength of this provisional verification of the efficacy of the function, point estimates of the proportions of southwest Kamchatkan and western Alaskan red salmon were obtained for each of 19 high seas samples taken in 1956 and 63 samples collected in 1957.

It was recognized that these point estimates were subject to two possible sources of variation. One of these sources is the random sampling variation in the probability of obtaining southwest Kamchatkan or western Alaskan red salmon in high seas samples. Another source of variation is attributable to the overlap in population characteristics of the southwest Kamchatka and western Alaskan morphotypes. That is to say, in drawing repeated samples from a population which overlaps to some extent with another population, variation can be expected in the ratio of correctly classified to misclassified individuals.

The following report will present the results of classifying the 1958 and 1959 red salmon collections using the 1956 discriminant function. The precision of the point estimates of western Alaskan red salmon in high seas samples will also be considered.

Procedures

Sampling

In 1958, sampling in inshore areas was similar to that for 1957 except that sampling was discontinued in the Aleutian Islands and the Columbia River. Due to inclement weather and apparent scarcity of red salmon in 1958, samples were fewer from the mid-Pacific Ocean and Bering Sea. However, more samples were available from the Gulf of Alaska.

The Japanese commercial fleet did not operate in the Okhotsk Sea in 1959, therefore, no samples were obtained from that area. For the first time since our studies began, however, a sample was obtained from a Kamchatka stream. This was a single sample obtained in a beach seine from the Ozernaya River on September 1, after the close of the active fishing season. On the high seas, both area coverage and numbers of red salmon taken were considerably improved over both 1957 and 1958.

Samples of less than 15 fish were excluded from the following analysis.

Classification (Discriminant Function)

The 1956 discriminant function which was used in classifying the 1958 and 1959 red salmon samples was of the form:

$$Y = 0.264431\,X_1 - 0.396849\,X_2 + 0.421494\,X_3 - 0.471575\,X_4 + 0.908622\,X_5 + 1.575538\,X_6 - 0.034089\,X_7$$

where X_1 is the number of scales along the lateral line, X_2 the total number of vertebrae, X_3 the vertebrae on which the first haemal arch occurs, X_4 the rakers on the ventral arm of the first left gill arch, X_5 the total number of rakers on the first left gill arch, X_6 the number of pectoral fin rays and X_7 the number of anal fin elements.

The mean functional values for the western Alaskan and southwest Kamchatkan populations were 70.431901 (Y_A) and 68.184330 (Y_B), respectively. The critical value, Y_0 was $\frac{Y_A + Y_B}{2} = 69.308115$. Specimens with Y (functional values) greater than Y_0 were classified as western Alaskan and specimens with Y less than Y_0 were classified as southwest Kamchatkan (Okhotsk Sea).

In applying this function, the errors of misclassification were weighted as described in INPFC Document 320 in accordance to the abundance of red salmon of the western Alaskan streams as estimated by escapements to these streams in 1958 and 1959 respectively.

Confidence Intervals for Point Estimates

Derivation of confidence limits for point estimates of the proportion of western Alaskan red salmon in high seas samples is discussed in a manuscript by Worlund (1960). Confidence intervals were computed from the equation:

$$V(\hat{F}_a)=\left(\frac{1}{P_{aa}-P_{ba}}\right)^2 \left(\frac{1}{m}\right) \left[\hat{F}_a\ (1-\hat{F}_a)\ (P_{aa}-P_{ba})^2 + \hat{F}_a\ (P_{aa}\ P_{ab}-P_{ba}\ P_{bb})+P_{ba}\ P_{bb}\right]$$

with $\hat{F}_a=\frac{r_a-P_{ba}}{P_{aa}-P_{ba}}$ and $r_a=\frac{m_{aa}+m_{ba}}{m}$

where:

m =high seas sample size
m_{aa} =number of individuals from population (a) correctly classified as being from (a)
m_{ba} =number of individuals from population (b) incorrectly classified as being from (a)
r_a =total proportion of sample classified as being from population (a)
P_{aa} =proportion of true population (a) correctly classified as (a)
P_{ab} =proportion of true population (a) misclassified as (b)
P_{bb} =proportion of true population (b) correctly classified as (b)
P_{ba} =proportion of true population (b) misclassified as (a)
$\hat{F}_a$ =the estimated proportion of population (a) in individual high seas samples
$V(\hat{F}_a)$=the variance of $\hat{F}_a$.

Then the approximate 90 per cent confidence interval for the point estimates is:

$$\hat{F}_a-1.645\sqrt{V(\hat{F}_a)} \text{ to } \hat{F}_a+1.645\sqrt{V(\hat{F}_a)}$$

Results

The average error in classification weighted according to the relative abundance of western Alaskan populations of red salmon is shown in Table 9. Some changes occur in the rate of misclassification for the western Alaskan streams. The average weighted errors of misclassification increased from 17.8 per cent in 1956–1957 to 22.6 per cent and 23.6 per cent, respectively, in 1958 and 1959.

Table 9. Average error of classification weighted according to the relative abundance of the contributing stocks of western Alaskan red salmon.

Area	Escapement in millions		Relative abundance		Observed per cent of misclassification		Weighted value	
	1958	1959	1958	1959	1958	1959	1958	1959
Naknek River	.2781	2.2326	.0873	.3052	35.1	28.6	3.0642	8.7287
Egegik River	.2463	1.0724	.0773	.1466	15.7	14.3	1.2136	2.0964
Ugashik River	.2795	.2192	.0878	.0300	13.4	14.1	1.1765	.4230
Kvichak River	.5348	.6697	.1680	.0915	18.9	22.6	3.1752	2.0679
Wood River	.9618	2.2107	.3020	.3022	25.4	23.6	7.6708	7.1319
Karluk River	.4636	.4442	.1456	.0607	29.3	32.5	4.2661	1.9728
Red River	.0948	.0842	.0298	.0115	20.6	16.9	0.6139	.1944
Chignik River	.3253	.3826	.1022	.0523	13.9	18.0	1.4206	.9414
Total	3.1842	7.3156	1.000	1.000			22.6009	23.5565

1958: *Average Errors in Classification*
Western Alaskan population (P_A) = 22.6009%
Southwest Kamchatkan population (P_B) = $\frac{20.00+32.77+27.43+36.13}{4}$
(P_B) = 29.0825%

1959: *Average Errors in Classification*
Western Alaskan population (P_A) = 23.5565%
Ozernaya River population (P_B) = 36.6412%

The average error in classification for the Okhotsk Sea sample was about 23.7 per cent in 1956–1957. In 1958, risk of misclassification increased to about 29 per cent and further increased to about 36.6 per cent in the single sample obtained from the Ozernaya River in 1959. It is not possible to evaluate the significance of this comparatively large error in classification from the latter single sample. The qualitative and quantitative relationship to the Ozernaya race (or races) of this sample which was obtained so late in the season cannot be established without supplementary biological information. For purposes of this analysis, however, this single sample was assumed

TABLE 10. Results of discriminant function analysis—1958 high seas red salmon samples.

Sample No.	Sampling date	Position of sample		Sample size	Per cent classified		Corrected per cent Western Alaska type	90 per cent confidence interval
		Longitude	Latitude		Western Alaska type	Southwest Kamchatka type		
1	7/ 5	156°28′E	48°55′N	112	38.39	61.61	19.3	4–35
2	7/19	159°50′E	50°35′N	114	36.84	63.16	16.1	1–31
3	7/26	159°51′E	51°58′N	116	33.62	66.38	9.4	0–24
4	6/16	160°27′E	49°21′N	115	36.52	63.48	15.4	0–31
5	7/29	164°00′E	55°00′N	48	27.08	72.92	0.0	0–22
6	8/ 7	164°00′E	55°00′N	62	40.32	59.68	23.3	2–44
7	6/25	166°35′E	49°35′N	111	35.14	64.86	12.5	0–28
8	6/21	167°00′E	59°01.5′N	19	15.79	84.21	0.0	0–36
9	6/15	167°14′E	50°41′N	116	28.45	71.55	0.0	0–14
10	5/16	168°15′E	50°10′N	117	44.44	55.56	31.8	16–47
11	6/17	169°03′E	59°16′N	20	10.00	90.00	0.0	0–35
12	5/26	169°41′E	47°30′N	109	39.45	60.55	21.5	6–37
13	7/31	170°38′E	59°18′N	90	15.56	84.44	0.0	0–16
14	5/29	171°30′E	51°05′N	105	28.57	71.43	0.0	0–15
15	6/ 5	171°35′E	52°02′N	97	46.39	53.61	35.8	19–53
16	6/ 7	172°30′E	50°50′N	116	57.76	42.24	59.4	44–75
17	6/ 1	173°00′E	54°00′N	15	33.33	66.67	8.8	0–50
18	5/16	173°19′E	49°21′N	100	44.00	56.00	30.9	14–48
19	7/18	175°00′E	52°00′N	51	43.14	56.86	29.1	6–53
20	7/18	175°00′E	55°00′N	17	23.53	76.47	0.0	0–38
21	7/15	178°00′E	54°00′N	17	35.29	64.71	12.8	0–52
22	7/12	178°50′E	50°59′N	49	40.82	59.18	24.3	0–48
23	6/30	180°00′	50°00′N	41	19.51	80.49	0.0	0–24
24	7/14	180°00′	53°31′N	23	60.87	39.13	65.8	31–100
25	7/ 6	175°53′W	51°17′N	37	40.54	59.46	23.7	0–51
26	7/ 7	175°00′W	50°30′N	17	47.06	52.94	37.2	0–78
27	8/ 5	175°00′W	51°30′N	70	52.86	47.14	49.2	29–70
28	8/ 6	175°00′W	50°00′N	83	61.45	38.55	67.0	49–85
29	8/ 7	175°00′W	49°00′N	35	42.86	57.14	28.5	0–57
30	6/18	172°30′W	56°00′N	75	66.67	33.33	77.8	68–100
31	8/10	170°00′W	50°00′N	36	61.11	38.89	66.3	39–94
32	8/11	170°00′W	51°00′N	63	47.62	52.38	38.4	17–60
33	6/17	170°02′W	53°30′N	50	68.00	32.00	80.6	58–100
34	6/26	170°04′W	55°58′N	22	81.82	18.18	100.0	70–100
35	6/25	169°24′W	55°04′N	78	70.51	29.49	85.7	68–100
36	8/15	166°00′W	52°51′N	28	60.71	39.29	65.5	34–97
37	8/17	165°00′W	52°00′N	40	37.50	62.50	17.4	0–44
38	8/18	165°00′W	51°00′N	37	62.16	37.84	68.5	41–96
39	8/19	165°00′W	50°00′N	36	47.22	52.78	37.5	9–66
40	6/ 7	150°00′W	55°00′N	75	61.33	38.67	66.7	48–86
41	6/ 8	150°00′W	55°00′N	27	51.85	48.15	47.1	14–80
42	6/ 9	150°00′W	55°00′N	19	57.89	42.11	59.6	21–98
43	6/15	155°00′W	55°00′N	88	61.36	38.64	66.8	48–84
44	6/16	155°00′W	55°00′N	16	50.00	50.00	43.3	1–86
45	6/23	155°00′W	50°00′N	19	57.89	42.11	59.6	21–98
46	6/24	155°00′W	50°00′N	44	38.64	61.36	19.8	0–45
47	6/25	155°00′W	50°00′N	20	80.00	20.00	100.0	68–100
48	5/24	145°00′W	50°00′N	25	28.00	72.00	0.0	0–34
49	5/25	145°00′W	50°00′N	29	62.07	37.93	68.3	38–99
50	5/27	145°00′W	50°00′N	63	47.62	52.38	38.4	17–60
51	6/ 4	145°00′W	58°00′N	66	31.82	68.18	5.7	0–25
52	6/ 5	145°00′W	58°00′N	78	37.18	62.82	16.8	0–35

to be representative of the entire Ozernaya River run.

Classification of the 1958 High Seas Samples

The results of classifying the 1958 high seas samples are listed in Table 10. Figure 26 shows the per-

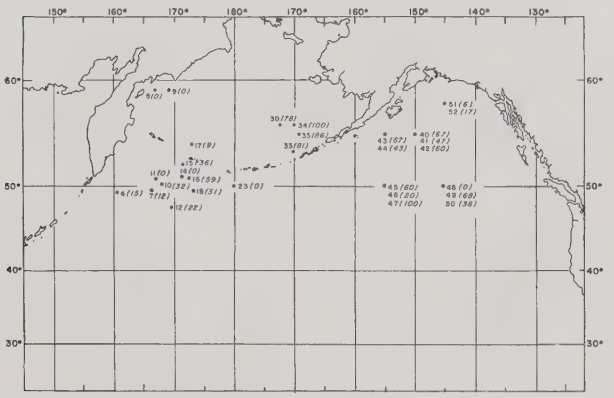


FIGURE 26. Percentage of samples classified western Alaskan type, May and June 1958. First number indicates sample number ; second number per cent western Alaskan type.

centage of high seas samples taken during May and June which classified as western Alaskan type. These are almost entirely maturing fish.

Samples available for our analysis are scant. In the Bering Sea, only seven samples were available. Samples 30, 33, 34 and 35 from the eastern Bering Sea were classified from 78 to 100 per cent western Alaskan type. No western Alaskan type salmon were indicated to be contained in samples 8 and 9 from the Olyutorskii-Karaginskii area. Nine per cent of sample 17 from north of Attu Island classified western Alaskan type. Excepting the Gulf of Alaska, all available samples from the North Pacific Ocean were taken west of 180°. These samples were classified from zero to 59 per cent western Alaskan morphotype.

Samples from the Gulf of Alaska classified from zero (sample 48) to 100 per cent (sample 47) western Alaskan. For reasons stated in INPFC Document 320, it is thought that the specimens from the Gulf of Alaska classifying as non-western Alaskan red salmon are from populations south of Cook Inlet in North America. However, the *a priori* bases for the 1956 discriminant function are not entirely applicable to the Gulf of Alaska and pending further analysis no further statement can be made concerning these samples.

An interesting feature is the rather abrupt and severe variations which occur in sampling three successive days at 50° N., 155° W. longitude and at 50° N., 145° W. longitude. At the former station, the percentage estimate of western Alaskan type fluctuated from 60 to 20 to 100 per cent while at the latter station, estimates varied from zero to 68 to 38 per cent. The cause of such short term variation is not yet identified.

All samples taken in July were obtained west of 175° W. longitude (Fig. 27). These are fish of several ages, both mature and immature. Five samples were

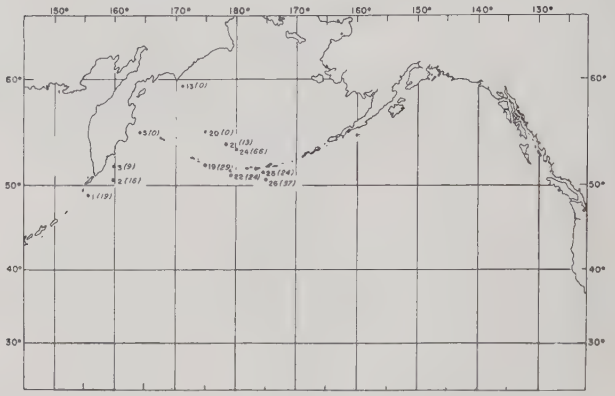


FIGURE 27. Percentage of samples classified western Alaskan type, July 1958. First number indicates sample number ; second number per cent western Alaskan type.

obtained from the Bering Sea of which three (samples 5, 13 and 20) were indicated to contain no western Alaskan reds. Samples 21 and 24 were classified 13 per cent and 66 per cent western Alaskan red salmon. The four samples taken in the North Pacific Ocean between 175° W. and 175° E. longitudes were classified from 24 to 37 per cent western Alaskan morphotype. Samples 1, 2 and 3 obtained from waters off southern Kamchatka Peninsula were classified from 9 to 19 per cent western Alaskan type.

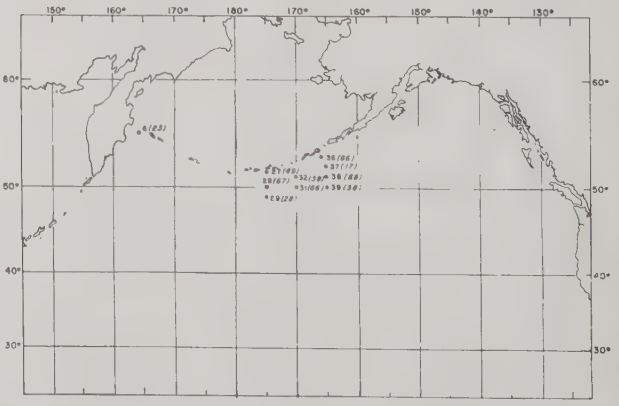


FIGURE 28. Percentage of samples classified western Alaskan type, August 1958. First number indicates sample number ; second number percent western Alaskan type.

TABLE 11. Results of the discriminant function analysis—1959 high seas red salmon samples.

Sample No.	Sampling date	Position of sample		Sample size	Per cent classified		Corrected per cent Western Alaska type	90 per cent confidence interval
		Longitude	Latitude		Western Alaska type	Ozernaya River type		
1	8/ 8	159°28′E	51°00′N	95	13.7	86.3	0.0	0–20
2	6/15	159°41′E	49°48′N	19	47.4	52.6	27.0	0–74
3	6/17	159°51′E	49°31′N	15	33.3	66.7	0.0	0–51
4	6/15	162°31′E	48°31′N	106	42.4	57.6	14.5	0–34
5	7/ 5	163°48′E	52°32′N	101	36.6	63.4	0.0	0–20
6	6/15	163°55′E	48°24′N	109	35.8	64.2	0.0	0–19
7	8/19	164°00′E	54°00′N	22	36.4	63.6	0.0	0–42
8	6/ 8	165°11′E	48°07′N	33	27.3	72.7	0.0	0–35
9	8/20	166°00′E	54°00′N	48	29.2	70.8	0.0	0–29
10	8/21	166°00′E	53°00′N	45	24.4	75.6	0.0	0–30
11	6/ 5	168°06′E	46°21′N	111	29.7	70.3	0.0	0–19
12	7/15	168°36′E	48°48′N	92	38.0	62.0	3.1	0–24
13	5/27	169°12′E	48°00′N	111	28.8	71.2	0.0	0–19
14	5/26	169°29′E	48°57′N	114	33.3	66.7	0.0	0–19
15	5/26	170°00′E	48°00′N	43	39.5	60.5	7.2	0–38
16	8/ 1	170°00′E	58°00′N	49	59.2	40.8	56.7	28–86
17	8/ 2	170°00′E	57°00′N	45	28.9	71.1	0.0	0–30
18	8/ 3	170°00′E	56°00′N	21	61.9	38.1	63.5	20–100
19	6/25	170°52′E	49°06′N	65	32.3	67.7	0.0	0–25
20	6/ 3	171°00′E	52°00′N	15	26.7	73.3	0.0	0–51
21	6/ 4	171°00′E	52°47′N	15	40.0	60.0	8.4	0–61
22	6/ 5	171°00′E	53°30′N	35	60.0	40.0	58.7	24–93
23	6/ 6	171°00′E	53°20′N	55	43.6	56.4	17.5	0–45
24	6/ 8	171°00′E	55°00′N	61	52.5	47.5	39.8	13–66
25	5/28	171°20′E	50°25′N	21	28.6	71.4	0.0	0–43
26	6/ 5	171°20′E	51°21′N	93	50.5	49.5	34.8	13–56
27	5/27	172°08′E	48°20′N	26	50.0	50.0	33.6	0–73
28	7/ 5	173°22′E	56°49′N	110	55.4	44.6	47.1	28–67
29	7/19	174°06′E	51°54′N	22	68.2	31.8	79.3	38–100
30	5/22	175°00′E	51°00′N	38	55.3	44.7	46.9	14–80
31	5/23	175°00′E	50°00′N	17	52.9	47.1	40.8	0–91
32	5/24	175°00′E	49°00′N	24	33.3	66.7	0.0	0–41
33	5/25	175°00′E	48°00′N	31	41.9	58.1	13.2	0–50
34	7/ 4	175°00′E	58°00′N	56	51.8	48.2	38.1	10–66
35	7/15	175°00′E	55°00′N	16	50.0	50.0	33.6	0–85
36	7/22	175°00′E	51°30′N	53	67.9	32.1	78.5	52–100
37	7/23	175°00′E	50°30′N	53	62.3	37.7	64.5	37–92
38	5/20	175°03′E	51°30′N	21	42.9	57.1	15.7	0–60
39	6/23	179°55′E	52°59′N	79	78.5	21.5	100.0	80–100
40	6/ 2	180°00′	51°00′N	74	73.0	27.0	91.4	70–100
41	6/13	180°00′	53°30′N	65	73.8	26.2	93.4	71–100
42	6/24	180°00′	54°00′N	20	80.0	20.0	100.0	61–100
43	6/25	180°00′	55°00′N	53	66.0	34.0	73.8	47–100
44	6/26	180°00′	56°00′N	128	71.9	28.1	88.6	72–100
45	6/27	180°00′	57°00′N	117	61.5	38.5	62.5	44–81
46	6/28	180°00′	58°00′N	39	46.2	53.8	24.0	0–57
47	6/30	180°00′	60°00′N	28	57.1	42.9	51.4	13–90
48	6/ 3	179°56′W	49°03′N	22	68.2	31.8	79.3	38–100
49	6/18	179°00′W	56°00′N	37	62.2	37.8	64.2	31–97
50	6/22	178°47′W	52°38′N	44	54.5	45.5	44.9	14–76
51	7/27	176°42′W	51°31′N	204	66.2	33.8	74.3	61–88
52	7/28	176°40′W	51°31′N	122	64.8	35.2	70.8	53–89
53	7/29	176°38′W	51°29′N	154	55.8	44.2	48.1	32–64

Table 11. (continued)

Sample size	Sampling date	Position of sample		Sample size	Per cent classified		Corrected per cent Western Alaska type	90 per cent confidence interval
		Longitude	Latitude		Western Alaska type	Ozernaya River type		
54	6/12	176°31′W	51°32′N	141	66.0	34.0	73.8	57–90
55	6/14	176°34′W	51°32′N	47	70.2	29.8	84.3	57–100
56	6/15	176°25′W	51°31′N	119	61.3	38.7	62.0	44–80
57	6/22	176°00′W	54°00′N	97	73.2	26.8	91.8	73–100
58	6/23	176°00′W	55°00′N	88	80.7	19.3	100.0	81–100
59	6/24	176°00′W	56°00′N	92	71.7	28.3	88.1	69–100
60	6/ 7	175°04′W	49°01′N	19	63.2	36.8	66.7	21–100
61	6/15	175°00′W	56°00′N	20	85.0	15.0	100.0	61–100
62	6/21	175°00′W	52°59′N	37	54.1	45.9	43.9	10–78
63	6/25	175°00′W	57°00′N	107	67.3	32.7	77.0	58–96
64	8/ 5	175°00′W	51°00′N	187	63.6	36.4	67.7	53–82
65	8/ 6	175°00′W	50°00′N	106	61.3	38.7	62.0	42–82
66	8/ 7	175°00′W	49°00′N	28	53.6	46.4	42.6	4–82
67	5/28	171°57′W	51°41′N	68	70.6	29.4	85.3	62–100
68	7/ 2	170°01′W	53°58′N	19	63.2	36.8	66.7	21–100
69	6/27	170°00′W	59°00′N	56	51.8	48.2	38.1	10–66
70	6/28	170°00′W	58°00′N	54	72.2	27.8	89.3	64–100
71	6/30	170°00′W	55°59′N	117	69.2	30.8	81.8	64–99
72	7/ 5	169°56′W	51°00′N	68	52.9	47.1	40.8	16–66
73	7/ 4	169°53′W	52°00′N	69	56.5	43.5	49.9	25–75
74	5/27	169°39′W	51°56′N	52	63.5	36.5	67.5	40–95
75	7/11	165°00′W	53°30′N	117	65.8	34.2	73.3	55–91
76	7/13	165°00′W	52°00′N	114	55.3	44.7	46.9	28–66
77	7/15	165°00′W	50°00′N	24	50.0	50.0	33.6	0–76
78	7/12	164°58′W	52°58′N	171	64.3	35.7	69.5	54–85
79	7/22	160°05′W	49°55′N	50	60.0	40.0	58.7	30–87
80	7/21	160°00′W	49°02′N	18	61.1	38.9	61.4	14–100
81	7/25	160°00′W	53°00′N	41	56.1	43.9	48.9	17–81
82	7/24	159°58′W	51°57′N	110	56.4	43.6	49.6	30–69
83	7/23	159°55′W	50°57′N	91	46.2	53.8	24.0	2–46
84	7/26	159°40′W	53°55′N	48	64.6	35.4	70.2	42–99
85	4/27	153°00′W	55°00′N	15	40.0	60.0	8.4	0–61

Sample 6 obtained in August at 55° N. latitude, 164° E. longitude classified as 23 per cent western Alaskan type (Fig. 28). The remaining samples were all taken between 175° W. longitude and 165° W. longitude south of the Aleutian Islands. These were classified 17 to 68 per cent western Alaskan.

Classification of the 1959 High Seas Samples

Table 11 lists the results of classifying the 1959 high seas samples. The percentages classified as western Alaskan type were grouped by month of capture and are illustrated in Figures 30, 31 and 32. The May and June samples are maturing fish. Subsequent samples include immature fish.

Sampling in May and June of 1959 (Fig. 29) was quite extensive and the best since our program began. The one sample from the Gulf of Alaska (actually taken April 27 but grouped with May-June collections) indicated the presence of but few western

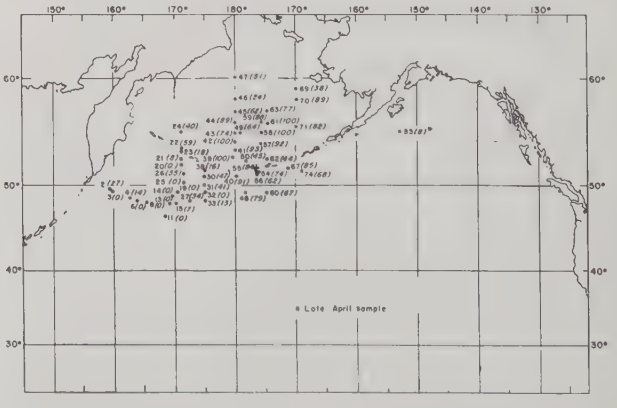


Figure 29. Percentage of samples classified western Alaskan type, May and June 1959. First number indicates sample number ; second number per cent western Alaskan type.

Alaskan red salmon (8 per cent).

In the North Pacific Ocean between 169° W. longitude and 180°, eight samples (Nos. 40, 48, 54, 55, 56, 60, 67 and 74) were classified from 62 to 91 per cent western Alaskan. At 175° E. longitude, samples 30, 31, 32, 33 and 38 were indicated to be 47, 41, 0, 13 and 16 per cent western Alaskan morphotype. West of 170° E. longitude, 6 of the 8 samples were indicated to contain no western Alaskan red salmon with sample 2 and sample 4 classifying 27 and 14 per cent, respectively.

In the Bering Sea, samples 69, 70 and 71 taken at 170° W. longitude were classified 38, 89 and 82 per cent western Alaskan type. Samples 57, 58, 59, 61 and 63 taken at 175° W. and 176° W. longitudes were classified 92, 100, 88, 100 and 77 per cent western Alaskan type. In sample 62, taken at 52° 59′ N., western Alaskan type dropped to 44 per cent. Western Alaskan type predominated in 6 of 7 samples taken at 180° (51 to 100 per cent). Twenty-four per cent of sample 46 were classified as western Alaskan type. Sample 50 at 52° 38′ N., 178° 47′ E. and sample 49 from 56° N., 170° W. longitude classified 45 and 65 per cent western Alaskan type. West of 180°, western Alaskan morphotype composed 100 per cent of sample 39, 59 per cent of sample 22, 40 per cent of sample 24 and 18 per cent of sample 23.

During the month of July (Fig. 30), in the Gulf of Alaska (east of 165° W. longitude), western Alaskan

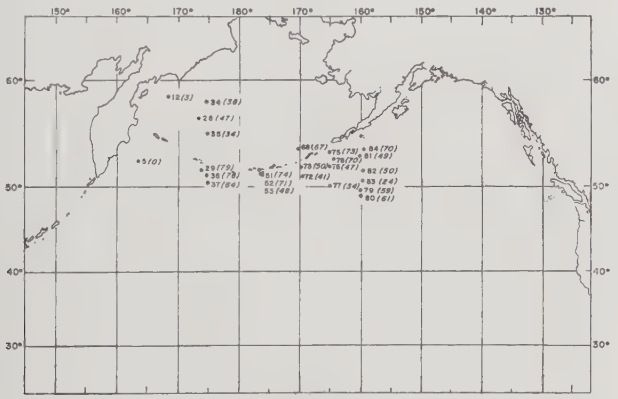


Figure 30. Percentage of samples classified western Alaskan type, July 1959. First number indicates sample number ; second number per cent western Alaskan type.

morphotype composed from 24 to 73 per cent of samples 75 through 84. In the North Pacific Ocean, samples 72 and 73 were classified 41 and 50 per cent western Alaskan. Samples 51, 52 and 53, south of Adak Island were classified 74, 71 and 48 per cent western Alaskan. Western Alaskan morphotype predominated samples 29, 36 and 37 taken south of the Near Islands (Attu-Buldir). Sample 5 was indicated to contain no western Alaskan red salmon.

In the Bering Sea, sample 68 was classified 67 per cent western Alaskan. Thirty-four per cent to 47 per cent of 3 samples taken between 175° E. and 173° E. longitudes were classified as western Alaskan morphotype. Only 3 per cent of sample 12 was classified as western Alaskan red salmon.

Only ten August samples were available for our analysis (Fig. 31). Three of these (samples 16, 17

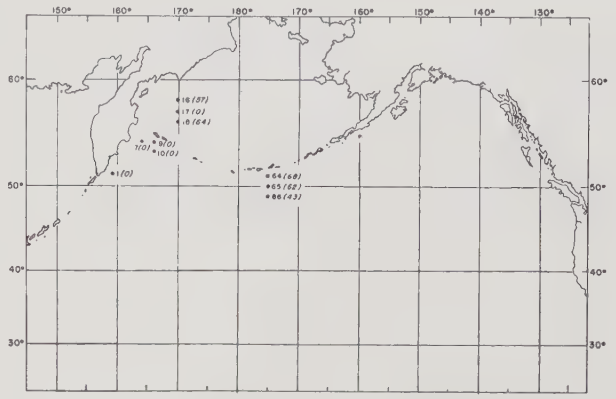


Figure 31. Percentage of samples classified western Alaskan type, August 1959. First number indicates sample number ; second number per cent western Alaskan type.

and 18) were obtained in the Bering Sea at 170° E. longitude on three successive days at latitudinal intervals of 1°. These samples were classified as 57, 0 and 64 per cent western Alaskan morphotype. In the North Pacific Ocean, samples taken at 175° W. longitude classified 43 to 68 per cent western Alaskan type none so classified in the four samples taken west of with 170° E. longitude.

Confidence Limits for the Point Estimates

Also shown in Tables 10 and 11, but not previously discussed, are the confidence limits for each of the point estimates. The 90 per cent level of significance was selected, since, for our present purposes, greater precision seems not warranted. Since the confidence limits here discussed are functions of both the errors in classification and sample size, the data from each table were categorized by sample sizes (m) in Table 12. The average half-interval for each group was plotted in Figure 32. Although basic data are not presented, for comparative purposes the half-intervals for the 1956 and 1957 point estimates are also included. Several tentative conclusions can be deduced from Figure 32.

TABLE 12. Range and average confidence intervals for different sample sizes.

	m=High seas sample sizes							
	15–24	25–49	50–74	75–99	100–124	125–149	150–200	200<
1958								
.95								
Range of limits	±37 to ±51	±27 to ±40	±24 to ±29	±20 to ±23	±17 to ±20			
Average limits	±45	±34	±26	±22	±19			
.90								
Range of limits	±30 to ±42	±22 to ±33	±20 to ±24	±16 to ±19	±14 to ±17			
Average limits	±37	±28	±21	±18	±16			
1959								
.95								
Range of limits	±48 to ±64	±34 to ±49	±26 to ±38	±22 to ±26	±21 to ±24	±20	±18 to ±19	±17
Average limits	±56	±40	±32	±24	±23	±20	±18	±17
.90								
Range of limits	±39 to ±52	±28 to ±40	±21 to ±31	±18 to ±22	±18 to ±20	±16	±14 to ±16	±14
Average limits	±46	±30	±26	±20	±19	±16	±15	±14

1958: Average error of misclassification=25.8417
1959: Average error of misclassification=30.0988

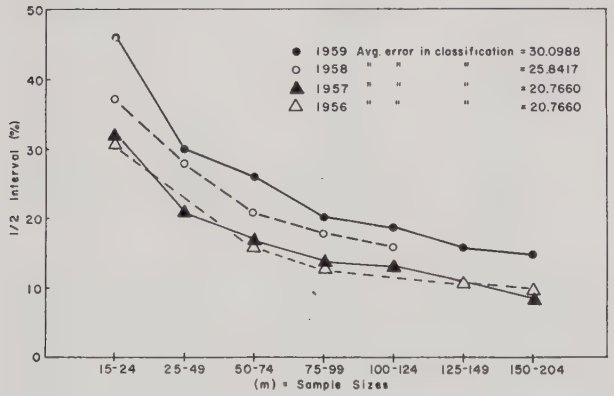


FIGURE 32. One-half confidence intervals for point estimates of western Alaskan red salmon in high seas samples of various sizes.

1. It is quite evident that on the average, sample sizes of less than 25 yield point estimates which are very coarse approximations (±31 to ±46 per cent). Precision in point estimates with half-intervals of 20 per cent or less occur only in samples with (m) greater than 75 where the errors in classification are about 25 per cent (1958) and 30 per cent (1959). With an average error in classification of about 21 per cent (1956–1957), samples of 50 fish or more yield confidence intervals of ±18 per cent and less. For the 1959 data, increase in sample size from 75–99 to 150–204 reduced the half-interval by only 5 per cent and from 100–124 to 150–204, the half-interval was reduced but 4 per cent. Therefore, in future sampling, we would consider that samples should be no less than 100 fish, no greater than 200 fish (except for special purposes), and preferably about 150 fish.

2. The leveling of the curve to the right of 75–99 in the 1959 data indicates that the limiting factor to greater precision is not so much sample size as the inherent error in classification. With the 1959 average error in classification of about 30 per cent, keeping sample sizes within practical limits (say, 100 to 200 fish), we can do no better than to place the point estimate within ±19 to ±15 per cent. For the 1956–1957 average errors in classification of 26 per cent and less, the same size samples may yield confidence intervals of ±16 to ±8 per cent.

3. The effects of different levels of errors in classification are illustrated in Figure 32. For the same size samples, the increase of approximately 5 per cent in errors of classification from 1956–1957 to 1958 increased the width of the half-interval from 3 to 7 per cent in 1958. Again, a 4 per cent increase of error in classification from 1958 to 1959 resulted in a 2 to 9 per cent increase in the width of the half-interval.

CONCLUSIONS

From the samples available, and assuming the point estimates to be the best available, the following may be concluded concerning the 1958 and 1959 red salmon collections.

Red salmon samples were rather few in 1958. During the months of May and June, in the Bering Sea only seven samples were available. Classification of these indicated that western Alaskan red salmon dominated to 172° 30′ W. longitude. No samples

were available from this longitude to 173° E. longitude, west of which few or no western Alaskan type were indicated. In the Gulf of Alaska, fish of western Alaskan morphotype were present in varying proportions as far south as 50° N. latitude. In the North Pacific Ocean, all samples were obtained west of 180°. With but one exception, southwest Kamchatkan morphotype dominated these samples.

Twelve samples taken in July of 1958 were obtained west of 175° W. longitude. In the Bering Sea, southwest Kamchatkan morphotype dominated the three samples taken west of 178° E. longitude, while western Alaskan morphotype dominated one sample taken at 53° 31′ N., 180°. Southwest Kamchatkan morphotype dominated all samples taken south of the Aleutian Islands between 175° W. and 175° E. longitudes (63 to 76 per cent). West of 165° E. longitude, southwest Kamchatkan type were indicated to dominate by 81 to 100 per cent.

In August of 1958, east of 175° W. longitude, both the proportions of western Alaskan red salmon and their dominance fluctuated rather markedly. However, in this area, for reasons previously stated, those classifying as southwest Kamchatkan morphotype are probably red salmon from North American areas other than those included in the discriminant function. The one sample taken east of Kamchatka Bay was dominated by southwest Kamchatkan type.

In 1959, during the months of May and June in the Bering Sea, fish of western Alaskan morphotype were generally dominant in most samples taken east of 180° with percentages diminishing to about 59 and 40 per cent in samples taken at 171° E. longitude.

In the North Pacific Ocean, between 175° W. longitude and 180°, all samples were dominated by western Alaskan morphotype. South of 50° N. latitude and west of 175° E. longitude, few western Alaskan type were indicated. North of 50° N. and west of 175° E. longitude, western Alaskan morphotype were indicated to represent from zero to 47 per cent of the available samples.

In July of 1959, general dominance of western Alaskan red salmon was noted in samples taken in the North Pacific Ocean between 174° E. longitude and 175° W. longitude, with fluctuations in dominance east of this longitude. In the Bering Sea, western Alaskan morphotype were indicated to compose from 34 to 47 per cent of samples taken as far west as 173° 22′ E. longitude.

Ten samples were available from sampling in August of 1959. In the Bering Sea at 170° E. longitude, western Alaskan morphotype dominated two samples. South of 54° N. latitude and west of 166° E. longitude, all samples were totally of southwest Kamchatkan morphotype. South of Atka Island, intermixing of the two morphotypes was indicated with the proportion of western Alaskan morphotype ranging from 43 to 68 per cent.

PINK SALMON MORPHOLOGICAL STUDIES

By Roger Pearson

The pink salmon collection of 1957 was the first which was considered to be sufficient for preliminary analysis to evaluate the utility of multivariate statistical analysis of morphological characters in differentiating between continental stocks of pink salmon. Results of analyzing these data are reported in INPFC Document No. 412, " Use of a discriminant function analysis in the morphological separation of Asian and North American races of pink salmon, *Oncorhynchus gorbuscha* (Walbaum)."

On the basis of a discriminant function considering three characters (number of vertebrae, number of dorsal fin elements and scale length of the first ten circuli from the focus) and using Kodiak-Cook Inlet and Olyutorskii-Karaginskii samples as continental reference morphotypes, North American populations occurring south of Cook Inlet were found to be quite distinguishable from pink salmon of major Asian areas. Indications were, however, that the characters used were inadequate as indices for separating pink salmon of the Alaska Peninsula, Aleutian Islands and northwestern Alaska from major Kamchatkan pink salmon populations. To obtain better separation between these areas, additional characters are being examined. This study is confined to scale characters since these are readily available from scale impressions even for specimens which have been discarded.

Until the additional scale characters are evaluated for usefulness as racial separators, pink salmon classificatory morphological studies will be held in abeyance.

CHUM SALMON MORPHOLOGICAL STUDIES

By Jack LaLanne

The chum salmon analyses to date have shown that the meristic characters under study do not provide the separation that is needed between Asian and North American chum salmon populations for the classification of individual chum salmon, (International North Pacific Fisheries Commission, Doc. No. 314, 1959). Chum salmon originating from Cook Inlet, Kodiak Island and the Arctic areas cannot be satisfactorily differentiated from Okhotsk Sea chum salmon samples, although stocks to the east and south of Kodiak Island can be readily distinguished. Tagging studies have shown that the former are important contributors to the high seas area under study. Additional means are needed to separate these areas.

The use of scale characters in conjunction with meristic characters would provide the maximum separation of chum salmon populations now possible.

Canadian biologists have made their chum salmon scale readings available for use in the chum salmon meristic-scale analysis. However, differences in the data requirements of the two units are such that it seems advisable for the U. S. to proceed with separate scale readings.

In collaboration with the scale analysts, effort is being directed toward assessing the sources of variation in reading scales and also evaluating within and between population variation of scale characters. Sources of variation in meristic characters are being re-evaluated. These analyses are a prerequisite to determining the best combination of scale and meristic characters for use in a multivariate analysis designed to enable classification of high-seas chum salmon into area of origin.

OCEAN MIGRATION OF PACIFIC SALMON REVEALED BY TAGGING AND RECOVERY

By B. F. Jones

The purse seine vessels *Commander*, 81 feet, and *Renown*, 85 feet, were chartered for the 1960 high seas tagging by the Fisheries Research Institute of the University of Washington. Both vessels left Seattle april 9 and returned Septepber 5. The *Renown* was inoperative from April 14 to 28 after going aground in Wrangell Narrows, Southeast Alaska.

Gear used in 1960 was similar to that of previous years with the exception of two innovations which streamlined and increased the efficiency of seining and fish handling.

The first was the use of a recently-developed snap-open ring in place of the conventional closed purse rings. In addition to speeding the fishing operation, this change allowed for fishing under more severe weather conditions. The second was the use of a modified Legaz outrigger and a special " Montara Float " to hold the " bunt-end " open after the seine was pursed. By preventing collapse of the net against the boat, this device reduced materially the injuries and scale loss to salmon before brailing.

All mature salmon and most immatures were tagged with 3/4-inch diameter red and white plastic discs, the same as those used in 1959. Some 1/2-inch diameter all white discs and 1/16-inch diameter white plastic tubes were used on immature salmon late in the season. The 3/4-inch discs have so far yielded a much higher return rate than either of the other two tags.

The use of MS-222 to reduce injury to the salmon during tagging was continued on some samples in 1960. Returns to date indicate no significant difference between recovery rates of anesthetized and non-anesthetized fish.

Fair weather in May and June permitted vessels to cover fishing areas along the full length of the Aleutians while mature salmon were available. Weather was poor during most of July and all of August, greatly curtailing fishing for immature salmon.

One of the principal goals in 1960 was to find and tag mature red salmon as far to the west as possible. Between May 15 and 31 the *Commander* fished from Amchitka Pass to Attu and back, and although greater numbers of mature reds were tagged than in previous years, they were apparently much less abundant than in the central and eastern Aleutian areas. Therefore, during June, the vessels concentrated in the Adak Island-Amchitka Pass area and in the Umnak Island-

Amukta Pass area.

Mature reds, chums, and pinks were abundant during late May and all of June. Reds were particularly abundant south of Adak and south of Umnak. Catches by Fish and Wildlife Service sampling vessels corroborated this. In both areas, movement was characteristically westward as in previous years. Seining also showed a strong northward movement through Amchitka (180°) and Amukta (172° W.) Passes.

There were many more pinks than in previous even-numbered years. They were numerous across the whole Chain, and most numerous near the central Aleutians.

During the season, 168 seine sets were made, yielding 16,524 salmon; an average of 98 per set. This compares with an average of 87 in 1959 and 73 in 1958. Totals caught and tagged by species are shown below.

	Red	*Chum*	*Pink*	*Silver*	*King*	*Total*
Number caught	5,516	9,426	1,361	14	207	16,524
Number tagged	5,127	8,741	1,321	14	170	15,373

Starting in 1960, the tagging data have been listed according to the new statistical area designations agreed upon by representatives of Canada, Japan and the United States. This system (Fig. 33) designates rectangles of 2 degrees of latitude and 5 degrees of longitude by 4 numbers keyed to the southwest corner of each rectangle. The first 2 digits indicate the longitude (leaving off the hundred) and the last 2 digits the latitude. An " E " preceding the number designates East Longitude; and a " W " is West Longitude; no letter is required for those rectangles that have 180° as their west border.

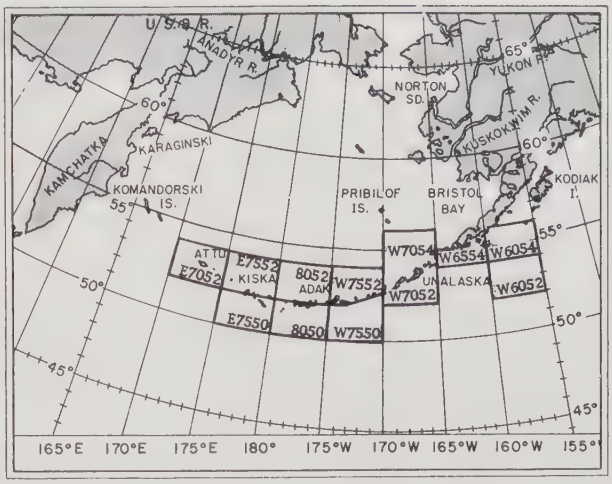


FIGURE 33. Numbered areas referred to in Table 13.

For purposes of the tagging data, this method has been modified slightly in a few areas where the Aleutian Islands bisect a rectangle. As illustrated in Figure 33, the lower right corner of area W 7552 has been added to area W 7550, and the upper left corner of area W 7052 has been added to W 7054, etc. Such modification was needed since there has been a considerable difference in abundance, movements, and timing of salmon on the north and south sides of the Islands. The modifications also avoid grouping together catches from areas which are oceanographically distinct. Table 13 presents a summary of tagging by area and species.

Recovery effort was considerably increased in 1960. The reward for tagged fish (with tag attached) was increased from $5.00 to $25.00. Reward remained $1.00 for tag not accompanied by fish. Fisheries

TABLE 13. 1960 Tagging totals by area and species.

Area[1]	Inclusive date	No. of seine sets	Numbers tagged by species					
			Red	Chum	Pink	Silver	King	Total
E7052	5/21-8/4	17	225	481	44	—	—	750
E7552	7/6-7/16	3	9	161	2	—	2	174
E7550	7/17-7/28	23	112	571	240	—	2	925
8052	5/16-7/18	7	187	72	3	—	—	262
8050	5/12-8/20	42	1,211	4,000	462	9	24	5,706
W7552	6/21-8/23	7	182	84	40	—	15	321
W7550	6/7-7/28	6	186	168	35	1	2	392
W7054	6/1-6/20	4	39	46	1	—	—	86
W7052	5/2-8/19	46	2,976	3,152	491	3	125	6,747
W6554	5/9-5/15	4	—	—	—	1	—	1
W6054	4/27-4/28	5	—	6	—	—	—	6
W6052	4/29	2	—	—	—	—	—	—
W4058	4/19	2	—	—	3	—	—	3
Total		168	5,127	8,741	1,321	14	170	15,373

[1] See Figure 33.

Research Institute personnel made repeated visits to Bristol Bay canneries to advertise the tagging program and to obtain length and scale samples from recovered fish. Field personnel of the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game in all districts of Alaska contributed materially in obtaining recovery data. In addition, a recovery crew was stationed at the tower counting site on the Kvichak River, where 28 tags were recovered.

The large number of red salmon tag recoveries in 1960 provided significant data on the timing of salmon movements from tagging to recovery locations. From Umnak Island to the Bristol Bay fishery, the mean time required was about 24 days. Later fish traveled slightly faster, averaging about 20 days. Those tagged near Adak required 26 to 40 days with a mean of about 33 days.

Since reds arrived in the Bristol Bay fishery in the same chronology as they were tagged, tag returns became a very useful management tool. With some knowledge of the trend of abundance of fish passing through the tagging areas, the arrival of the various tag numbers in the fishery signaled the progress of the run. The fact that the group tagged near Adak arrived later is also significant, since it indicated that the Bristol Bay run was composed of segments following separate routes at sea which were clearly separated also by time of arrival. Thus the Japanese operation north of Adak this year probably placed its entire burden upon only one part of the run.

Asian coastal returns from the USSR fishery agency are yet to be received. To date, private individuals have sent three tags from Russia. When returns are complete from Asia, the distribution picture of pinks and chums may change markedly.

Tag returns from the 1960 experiments received through January 4, 1961 are shown in Table 14. The numbers of mature salmon tagged are preliminary pending final determination of age and maturity. Recoveries are listed according to 3 categories: Asian coastal, high seas and American coastal. Percentage returns of reds is more than double the 1959 rate (24.1% vs. 11.4%).

Factors contributing to the high return in 1960 were:

1. The $25.00 reward offered for fish with tag attached.
2. Seven days' fishing throughout most of the season.
3. Increased personal contact with fishermen and canneries throughout the season.
4. The use of large brightly-colored disc tags easily seen by fishermen.
5. Improved condition of fish at release brought about by use of a bunt float and outrigger which kept bunt open at all times.
6. Increased recovery effort at the Igiugig tower site.

Table 14. Returns in 1960 of mature salmon tagged in 1960 (as of January, 1961).

Species	Red	Chum	Pink	Silver	King	Total
No. *matures*[1] tagged	2552	2500	1321	14	—	6387
Asian coastal returns[2]	—	1	2	—	—	3
High seas returns	86[3]	27	32	—	—	145
American coastal returns	528	52	9	—	—	589
Total	614	80	43	—	—	737
Percentage	24.3	3.2	3.3	—	—	11.6

[1] Maturity breakdown is preliminary estimate based on lengths, dates of tagging, and lengths of returns to date. It is probably more reliable for reds than for chums.
[2] USSR returns not yet received.
[3] Including 2 reds classified as immature at tagging that were taken at sea in 1960. (see text)

Table 15. Retruns in 1960 of salmon tagged in 1959 (as of January, 1961).

Species	Red	Chum	Pink	Silver	King	Total
No. *immatures* tagged	2699	2593	—	—	145	5437
Asian coastal returns[1]	—	—			—	—
High seas returns	4	2	—	—	2	8
American coastal returns	5	3	—	—	—	8
Total	9	5	—	—	2	16

[1] USSR returns not yet received.

TABLE 16. Returns in 1960 of salmon tagged in 1958 (as of January, 1961).

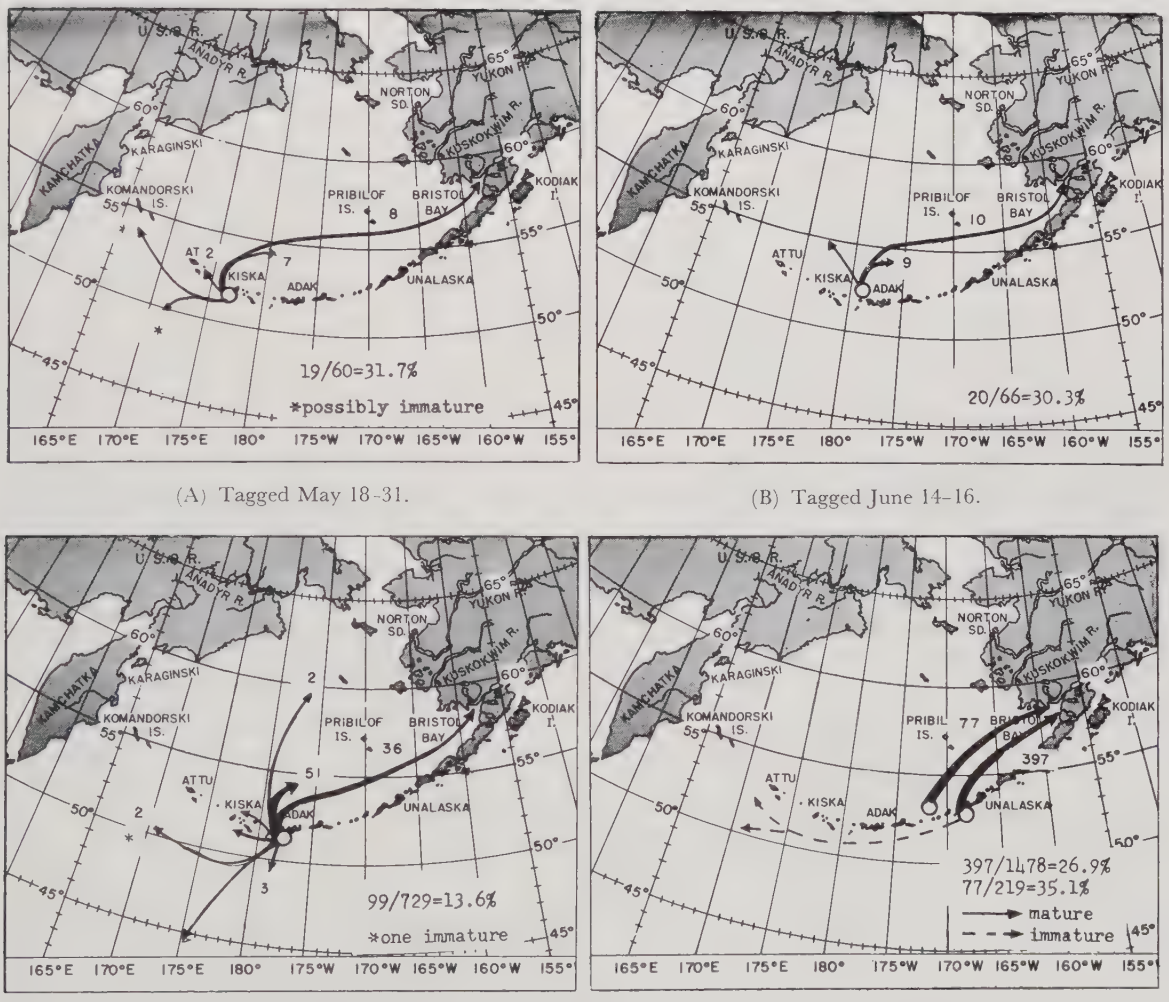
Species	Red	Chum	Pink	Silver	King	Steelhead	Total
No. *immatures* tagged	3661	8207	—	—	126	46	12,040
Asian coastal returns[1]					—	—	—
High seas returns	9	13	—	—	1	—	23
American coastal returns	7	—	—	—	—	1	8
Total	16	13	—	—	1	1	31

[1] USSR returns not yet received.

TABLE 17. Returns in 1960 of salmon tagged in 1957 (as of January, 1961).

Species	Red	Chum	Pink	Silver	King	Steelhead	Total
No. *immatures* tagged	1192	5477	—	—	113	11	6,793
Asian coastal returns[1]	—	—			—	—	—
High seas returns	—	4	—	—	—	—	4
American coastal returns	—	—			—	—	—
Total	—	4	—	—	—	—	4

[1] USSR returns not yet received.



(A) Tagged May 18–31.

(B) Tagged June 14–16.

(C) Tagged June 1–20.

(D) Tagged June 9–July 2.

FIGURE 34. Recovery distribution of red salmon tagged and recovered in 1960.

Tables 15, 16, and 17 show the continental distribution by species of the salmon tagged in 1959, 1958, and 1957, respectively, and recovered in 1960.

Of 60 reds tagged west of 180° in May, 1960, 19, or 31.7%, have been returned (Fig. 34-A). Of these, 8 were returned from Bristol Bay; 7 from high seas areas clearly on the route toward Bristol Bay; 2 taken on the high seas between Kiska and Attu cannot be classified as to continent of origin; and 2 caught south and west of Attu, were possibly immature, even though they were classified as mature at tagging. The dates of recovery (July 16 and 24) of the last two fish and their lengths at tagging (48 and 50 cm.) suggest that they could have been immature.

Figure 34-B illustrates the returns from 66 mature reds tagged just north of Amchitka Pass (180°). Ten went to Bristol Bay, 9 were taken at sea between the point of tagging and Bristol Bay, and 1 was recovered northwest of the tagging location. Since the direction of the seine sets showed these reds were moving north at time of tagging, Amchitka Pass (180°) is shown as an important avenue into the Bering Sea for reds destined for Bristol Bay. Total return was 30.3% from experiments in this area.

The 729 *mature* reds tagged south of Adak and Amlia Islands (173°–177° W) yielded 99 returns as shown in Figure 34-C. Thirty-six were from Bristol Bay and 63 from areas at sea which again clearly show the movement westward to Amchitka Pass, then northward and eastward toward Bristol Bay. One tagged June 20 was recovered July 28 south of Attu and was probably either an Asian red or local Aleutian red or it may have been immature. The one remaining return shown near Attu was classified as immature at tagging, 47.5 cm., July 10, and cannot be classified as to probable continent of origin. The one return from near 44° N. and the two from near 59° N. are considerably outside the pattern and may be errors in recording location.

The overall per cent return from Adak area tagging was 13.6%, which is considerably less than the 31.7% and the 30.3% found for the other areas discussed. Some Asian returns may be yet to come, but judging by the few high seas returns from western areas, these will probably be few.

South of Umnak Island (168° W.) and north of Amukta Pass (172° W.), 1,697 *mature* reds were tagged, yielding 474 returns (27.9%) from Bristol Bay (Fig. 34-D). Since none were intercepted by the Japanese fleet, this group must have entered the Bering Sea via Amukta Pass. The two recovered south of Attu (dotted arrows) were classified as immature at tagging. One was tagged June 28 (45.5 cm.) and recovered August 3 (52.2 cm.); the other was tagged June 30 (47.0 cm.) and recovered July 28 (48.0 cm.).

Thus, reds destined for Bristol Bay in 1960 approached via at least two major routes; one through Amukta Pass (172° W.) and one through Amchitka Pass (180°). Only the group approaching via Amchitka Pass was fished heavily by the Japanese high seas fleet.

Figure 35 illustrates returns in 1960 of reds tagged as immatures in 1958 (solid line) and in 1959 (dotted

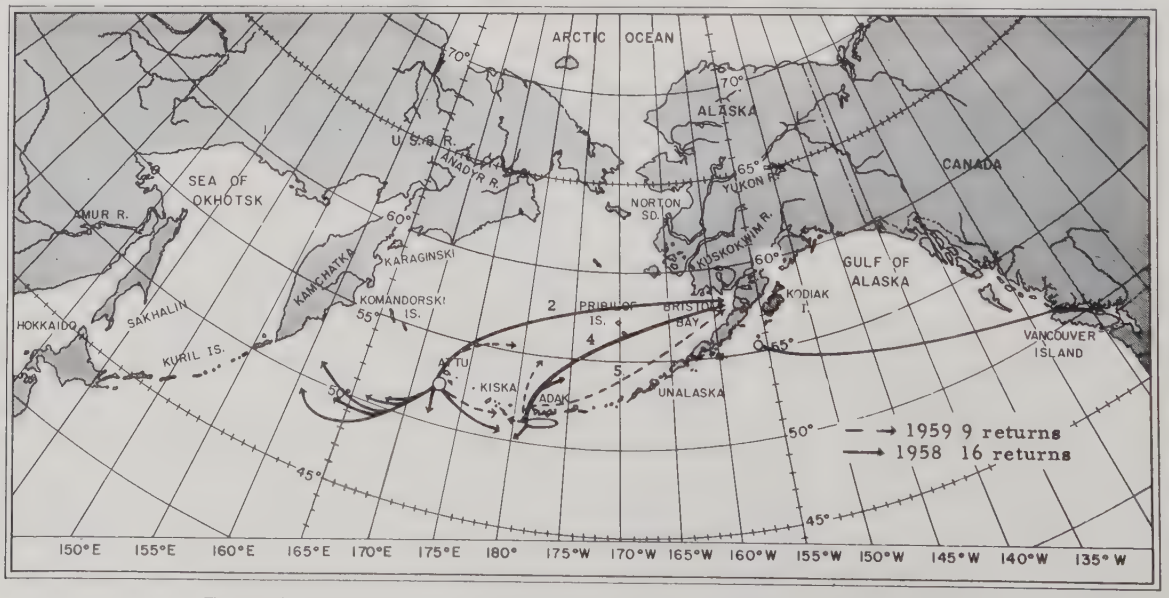


FIGURE 35. 1960 recovery distribution of red salmon tagged in 1959 and 1958.

line). All those tagged in 1958 had spent one winter at sea when tagged. Their lengths at tagging were between 30.0 and 42.0 cm. In 1960, therefore, these had spent three winters at sea. Five reds tagged near Attu in 1958 were recovered to the west and one nearly due south of Attu. Judging by the dates of recapture (July 6, 8, and 9), it is probable that three were en route to Asian spawning grounds. The remaining three could very well have been Bristol Bay reds considering the recovery dates (June 3, 6 and 12) and daily rate of travel of the species. Two from the same area were recovered in Bristol Bay, and one on the high seas en route to Bristol Bay.

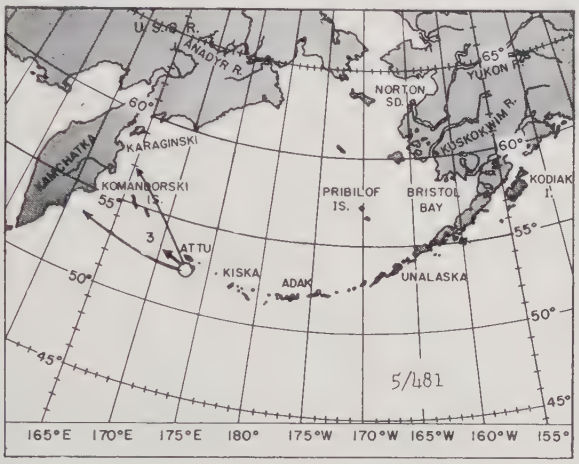
From 1958 releases south of Adak, four were recovered in Bristol Bay, one from the high seas en route to the Bay, and one south of Adak.

A single red return from 1958 releases south of Kodiak Island was returned from a cannery in Blaine, Washington.

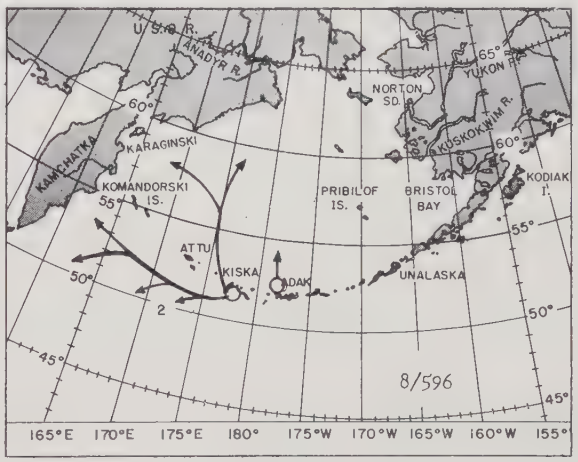
From 1959 releases near Attu, the two high seas returns probably were destined for Alaska, since they were returned from areas where nearly all reds in 1960 were shown to be Alaskan. Both had spent two winters at sea when tagged in 1959, so there is little doubt that they were maturing in 1960.

Tagging south of Adak in 1959 yielded five returns from Bristol Bay in 1960 plus two from the high seas on the route toward Bristol Bay.

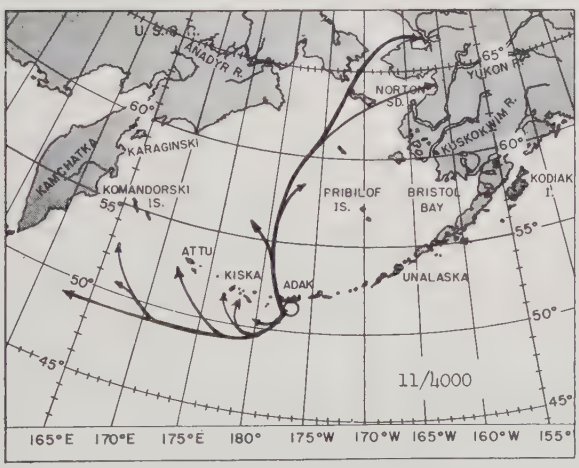
Figures 36-A, B, C, and D illustrate chum returns from 1960 experiments. To date, 80 chum salmon have been returned, 27 from the high seas, 51 from northwestern Alaska, one from USSR, and one from the British Columbia Coast. Additional USSR returns are yet to be received. Most returns from experiments in the Umnak-Unalaska area came from



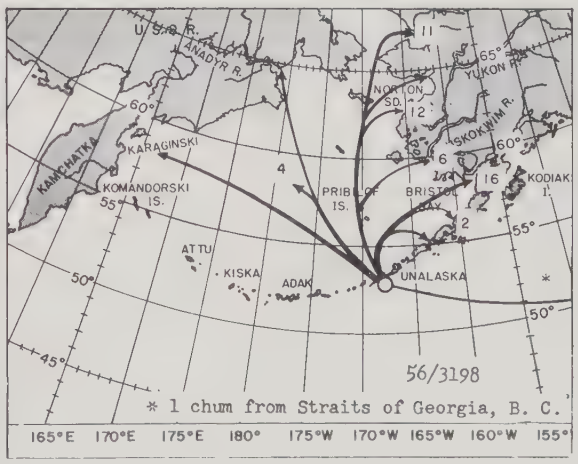
(A) Tagged May 21 -May 29.



(B) Tagged May 17 July 17.



(C) Taged May 12–July 27.



(D) Tgged May 18 -August 2.

FIGURE 36. Recovery distribution of chum salmon tagged and recovered in 1960.

northwestern Alaska. Returns from experiments in the Adak to Attu area were nearly all from the high seas west of the point of tagging. In addition to the above, 22 chums were returned in 1960 which had been tagged as immatures in previous years (4 in 1957, 13 in 1958, and 5 in 1959). Distribution was similar to that of previous years.

Forty-three pink salmon have been returned to date, 34 from the high seas and 7 from northwestern Alaska (Fig. 37). In addition, one was recovered in a stream on Adak Island and one from the commercial fishery on Unalaska Island. The locations of high seas returns show clearly that Karaginski pinks were well represented, even in the eastern Aleutians. Re-

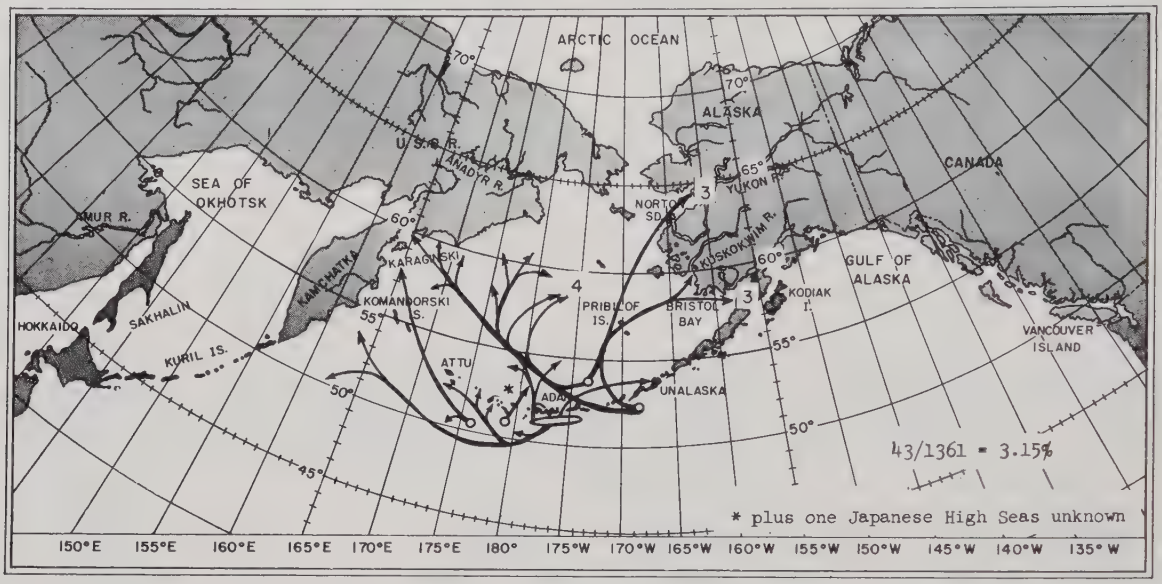


FIGURE 37. Recovery distribution of pink salmon tagged and recovered in 1960.

TABLE A. Release and recovery data for 49 U.S. salmon tags returned by Japan and USSR between February 10 and April 1, 1961.

Tagging area*	Year tagged	Year recovered	Species	Recovery areas and numbers recovered						Total
				Hokkaido	Sakhalin	Okhotsk Sea	East Kamchatka	Anadyr River	USSR unknown	
E7052	1960	1960	C	1	—	4	–	–	—	5
"	"	"	P	—	—	–	1	–	—	1
E7550	"	"	C	2	—	5	–	–	—	7
"	"	"	P	–	–	–	1	–	–	1
8052	"	"	C	–	–	–	—	—	1	1
8050	"	"	C	1	–	–	—	—	—	1
"	"	"	P	–	–	–	1	—	–	1
W7550	"	"	P	–	—	–	1	—	–	1
W7054	"	"	C	1	–	–	—	—	–	1
W7052	"	"	C	14	1	–	4	—	–	19
E7052	1959	1960	C	–	—	2	–	–	–	2
8056	"	"	C	–	–	–	1	–	–	1
8050	"	"	C	–	–	1	–	–	–	1
W7052	"	"	C	–	–	–	–	1	–	1
E7052	1958	1960	C	1	–	1	–	–	–	2
E7550	"	"	C	1	–	1	–	–	–	2
8050	"	"	C	–	–	1	–	–	—	1
8050	1956	1959	C	–	–	1	–	–	—	1
		Total		21	1	16	9	1	1	49

* See Fig. 33.

turns from the USSR are needed to complete the pink distribution picture. Northwestern Alaskan pinks were shown to be present only to 173° West Longitude, but some high seas returns from central Aleutian tagging may have been en route to northwestern Alaska also.

No silver or king salmon tagged in 1960 have been recovered.

Two kings tagged in the Bering Sea north of Adak in 1959 were recovered in 1960. One was taken near Karaginski on the east Kamchatka coast and the other approximately 200 miles northwest of tagging location.

One king salmon tagged near Adak in 1958 was recovered approximately 400 miles south of Attu.

A steelhead tagged September, 1958, southwest of Kodiak Island was recovered February, 1960, in a fish hatchery at Alsea, Oregon. This fish had been fin-clipped and released from the same hatchery approximately 5 months before it was caught and tagged near Kodiak.

Supplement

Since submission of the report on U. S. high seas tagging for 1960, an additional 28 tags were received from the USSR and 21 from Japan. Only 3 tags had been received from Asian coastal areas when the report was written, so the recent 49 returns are an important addition. Table A summarizes these returns by year and area of tagging and by general area of recovery.

KING CRAB INVESTIGATIONS

By T. Miyahara

The eastern Bering Sea king crab fisheries from 1953 through 1958 were relatively stable. Crabs were taken by both Japanese and United States fisherman, but the bulk of the annual catch of 1.2 to 1.6 million adult male king crabs was taken by the Japanese with the factory-mothership *Tokei-maru*. During this period, their annual production quota was 59,850 cases of king crab meat.

In 1959, the eastern Bering Sea king crabs were subject to increased fishing pressures. The full degree of increase is not yet known, but it has been reported that in addition to the increase to 70,000 cases of the Japanese quota, the Russians also began a mothership-type operation for eastern Bering Sea king crabs.

In early April of 1960, a Russian mothership with a fleet of about twelve tangle-net pick-up boats (Kawasaki type) and two or three exploratory-net setting vessels of about 100 feet in length arrived off Amak Island. Shortly thereafter, the *Tokei-maru*, with an 80,000 case quota, arrived with her usual fleet of eight Kawasaki boats and three net setting-exploratory vessels. United States fishermen also actively fished for king crabs in the area with a total of seven trawlers. In May 1960, a second Japanese operation was licensed by the Japan Fisheries Agency to catch and freeze king crabs, herring and bottom fish.

In addition to the kind crab fleets mentioned above, the Soviet bottom fish fleet, composed of an 11,000 ton mothership, 10 or 12 refrigerator ships and approximately 40 trawlers, and the Japanese bottom fish fleets, composed of five motherships, each of about

Table 18. Summary of tag releases and recoveries [1].

Tagging Year	Number tagged	Recoveries during							
		1954	1955	1956	1957	1958	1959	1960[2]	Total
1954	1,107	44	60	1	2	1	0		108
1955	1,351		32	53	35	18	12	6	156
1956	4,063			53	197	114	67	49	480
1957	13,795				39	192	235	182	648
1958	9,851					40	118	123	281
1959	4,447						41	77	118
1960	1,327							0	0
Total	35,941	44	92	107	273	365	473	437	1,791

[1] The table is presented to show the magintude of releasses and recoveries. Since each year's tagging experiment varied in sexes, size, and area, the data are not directly comparable.

[2] Incomplete.

10,000 tons, and a total of approximately 130 trawlers, are assumed to be taking some king crabs. The extent of these fishing efforts is so great that even the incidental catch of king crabs could be of major magnitude.

In view of this increased fishing intensity, need for early determination of the effect on the king crab population is emphasized.

During the 1960 field season, a vessel was chartered as in each year since 1955. The 80 foot halibut schooner *Paragon* fished at a series of stations to collect data needed for studies on growth, abundance, migrations, mortalities, and environmental conditions. Although the vessel was used for king crab studies for only one month, 70 stations were covered. All crabs caught were measured and males tagged and released. Table 18 summarises by years the numbers of king crabs tagged, released and recovered.

Tagging experiments have been highly useful in the study of growth. A draft report[1] covering the growth of adult male king crabs was presented for review at the 1959 Annual Meeting of the International North Pacific Fisheries Commission. After review and changes, it is now ready for publication.

Although king crab growth rates developed have not been related to actual age, it is tentatively estimated that four-year-old crabs would be approximately 80 mm. in carapace length. Based on this estimate, a comparison of our age-growth relationship with those presented by other researchers, namely, Marukawa[2], Nakazawa[3] and Wang[4], is presented in Figure 38. Since they presented their results in terms of carapace width, all curves are so shown, although present researchers generally use the more definite and accurate length dimension.

Wide differences in growth rates are indicated, and though the difference may in part be due to geographic separation, it does appear possible that there

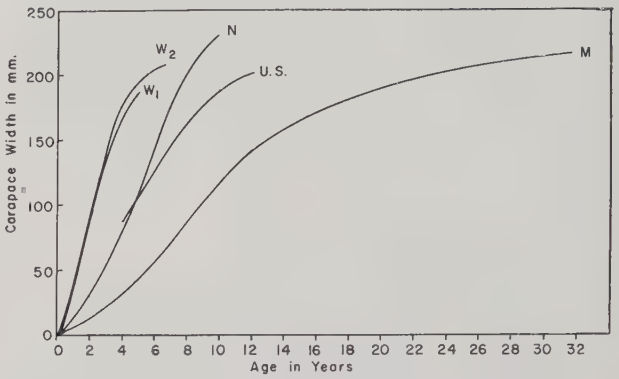


FIGURE 38. King crab growth curves. W_1 and W_2 derived from Wang (1937) for crabs from northern Hokkaido and Sakhalin, respectively; curve N from Nakazawa (1912) and curve M from Marukawa (1933), all from published reports. Curve U.S. from United States King Crab Investigation results.

are some errors in interpretation and demonstrates the difficulties in estimating growth of king crabs.

Marukawa's growth curve, based on molting increments exhibited by reared crabs and modes in a size frequency distribution, indicates very slow growth. McKay and Weymouth[1], in reviewing Marukawa's work, point out the possibility that early modes in the size frequency distribution are instars rather than year classes and the later modes are probably due to chance irregularities. We concur with the reviewers, since progressions of modes in a series of size frequencies taken throughout a year indicates greater difference between year classes than is shown by the modes in Marukawa's frequency distribution. That the later modes are due to chance irregularities is suspected, since our observations of increments resulting from one molt would span from three to six modes. If some of the early modes were considered as instars rather than year classes, the lower portion of Marukawa's curve would be steeper and would shift the remainder of the curve to the left. Consideration of fewer age classes in the larger sizes would also steepen the curve and it would approach maximum size more rapidly.

Nakazawa's curve lies intermediate between that of Marukawa and Wang, and somewhat similar to ours. The major difference is in the slope of the curve above 100 mm. Nakazawa's report unfortunately does not include data which would allow more detailed comparison. However, he assumes an annual molt, which is contrary to our findings and which

[1] Weber, Douglas D. and Takashi Miyahara. 1959. Estimated growth of the Southeastern Bering Sea adult male king crab population. INPFC Doc. No. 318, 15 p.

[2] Marukawa, Hisatoshi. 1933. Biological and fishery research on Japanese king crab *Paralithodes camtschatica* (Tilesius). *Journal of the Imperial Fisheries Experimental Station*, Tokyo, No. 14, Paper No. 37, 152 p. In Japanese with English abstract.

[3] Nakazawa, Kiichi. 1912. A study on the Hokkaido king crab (Hokkaidosan tarabagani no kenkyu). Tokyo, *Dobutsugaku Zasshi* (Zoological Magazine) vol. 24, No. 279, pp. 1–13. In Japanese.

[4] Wang, Yi-Kuan. 1937. On the stock of the crab, *Paralithodes camtschatica* (Tilesius) in the seas of Hokkaido and Saghalin. *Bulletin of the Japanese Society of Scientific Fisheries*, vol. 5, No. 5, pp. 291–294. In Japanese with English synopsis.

[1] MacKay, Donald C.G. and Frank W. Weymouth. 1935. The growth of the Pacific edible crab, *Cancer magister* Dana. *Journal of the Biological Board of Canada*, vol. 1, No. 3, pp. 191-212.

could very easily account for the fast growth rate of the larger sizes. It is interesting to note that Nakazawa's curve for the first two years is essentially the same as that postulated for juvenile crabs by U. S. researchers in the 1959 annual report.

Wang shows rapid growth based on size frequency distributions and also on the progression of modes in samples taken in three successive years. The smallest mode observed was at 45 mm. which he concludes are crabs one year old. There is, however, general agreement among most investigators that at age one, crabs are about 7 to 10 mm. in carapace width. Our studies indicate that at least one and possibly two years span of time is required for an 8 or 9 mm. crab to grow to 45 mm.

In summary, it appears that Marukawa's assignment of ages to the range of male king crab sizes is high and and that Wang's may be low.

The tagging experiments have provided additional information on other phases of the king crab investigations. Examination of data on tags recovered during the year of release provides information on rates of movement.

Movement rates calculated from the straight line distances and numbers of days between release and recovery, show ranges of 0 to 10.6 miles per day with a mean of 1.3 miles per day.

Tag release and recovery information has also been analyzed to assess the degree of movement from one area to another. In the analysis, the eastern Bering Sea king crab fishing area has been divided into six sub-areas. For this purpose, recoveries made within the year of release have not been considered, since they would not all have had time to move into other areas. The actual number of tag returns made in any area is the result of two influences, (1) the intensity of fishing in the areas, and (2) the movement of crabs into the areas fished. From the total number of recoveries made from releases in each sub-area and the total units of fishing effort expended over the entire area, a ratio of tag recoveries to units of effort was calculated. This ratio was then applied to the actual amount of effort in each area to calculate expected recoveries which were then compared with actual recoveries in each area.

The areas considered, the calculated expected and actual recoveries from tags released in each area, are presented in Figure 39. Arrows indicate the release to recovery relationships, and the numbers within each area are the expected (upper numeral) and the actual (lower numeral) recoveries. All expected and actual

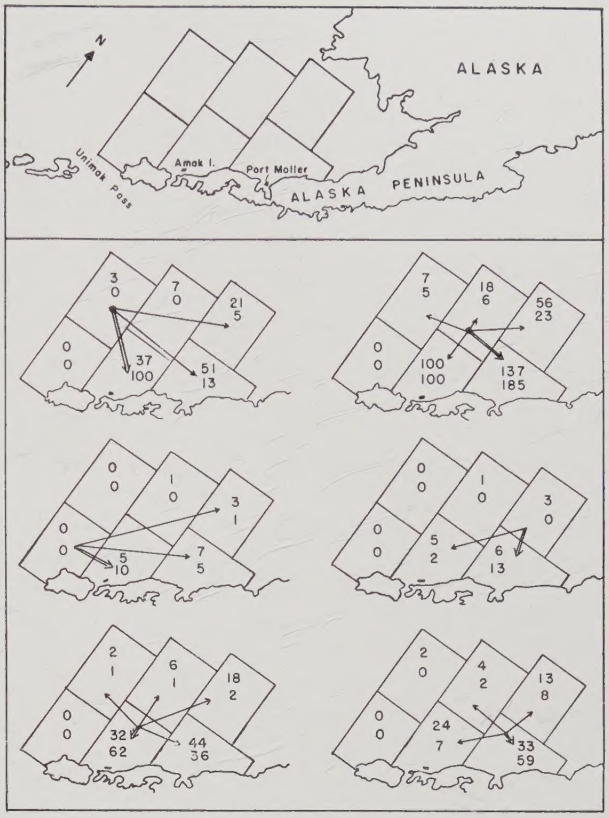


FIGURE 39. Dispersion of tagged male king crabs from various release areas. Arrows indicate the relation of tag release to recovery areas. The upper number in each area is the calculated expected and the lower, the actual number of tags recovered in each area.

return values are included in the figure, although fishing effort and/or returns in some cases have been insufficient to have significance.

Except in a few instances, the actual recoveries deviate from the expected, indicating that tagged crabs migrated to some areas more heavily than to others. The values indicate that crabs appear to congregate in two localities; one inshore off Amak Island and another inshore off Port Moller. It is noted that releases made in the Amak Island area and the areas to the northwest and west appear to be most strongly represented in the Amak area, while releases from other areas are most strongly recovered in the Port Moller area. It is obvious that the present fishery which is concentrated in the Amak Island and Port Moller areas is catching crabs from the entire area covered by the United States station pattern surveys.

Trawl surveys for the purpose of developing estimates of distribution and abundance have been a major phase of study and various aspects of the 1958 surveys

were analyzed. Particular emphasis has been placed on the 1958 surveys since area coverage was most complete.

The data show that occurrences of the smallest male crabs taken in the surveys are limited to the northeastern part of the station pattern, while the distribution of larger crabs is more widespread, appearing as concentrations in other portions of the survey area. This suggests that recruits may come from the more shallow peripheral areas where large numbers of juvenile crabs have been observed.

Abundance estimates for the total number of crabs in the southeastern Bering Sea were obtained by expanding each survey catch per unit area covered by the trawl. The estimated abundance of king crabs on the grounds during May of 1958 was 59,377,000, of which 20,908,000 were females, 30,511,000 were recently molted males, and 7,958,000 were old shell males. Of the old shell males, 1,191,000 were less than 132.5 mm. carapace length and 6,767,000 were greater. A tentative assessment of the reliability of the estimates suggests that at the .80 level of confidence, the estimate for total number of crabs is within 29 per cent of the actual number.

Pertinent in evaluating catch and production is information on the varying amount of meat in crabs. This variability which appears to be associated with the molting cycle is significant. The live weight and total meat weight of 22 new shell and 30 old and very-old shell adult male king crabs were sampled during 1958 through 1960. The live weights, meat weights and percentage recovery by size are plotted on Figures 40 and 41. The data show that there is little difference between live weights of the new and of the old and very-old shelled crabs. The total meat weight, however, shows greater difference. Expressed in percentages of meat weight to live weight, the mean recovery was 21.2 for new shell crabs and for old and very-old shell crabs, the recovery was 31.6 per cent.

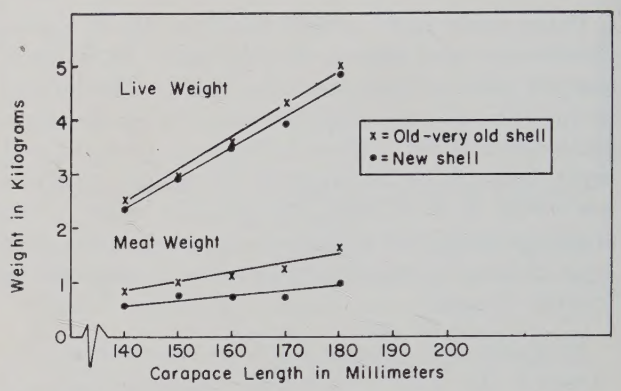


FIGURE 40. Mean live and meat weights by carapace length of old-very old and new shell adult male king crabs. Line is fitted by inspection.

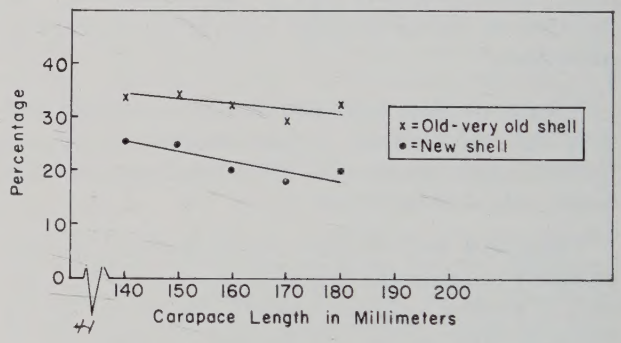


FIGURE 41. Recovery in terms of percentage meat to live weights of commercial size male crabs. Line is fitted by inspection.

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Errate:

The following corrections should be made in the *1959 Annual Report:*

Page 74, right hand column, fifth line:

"8-9 crabs per tan of scouting nets" *should be* "89 crabs per tan of scouting nets"

Page 77 Table 5:

"merum" *should be* "merus"